THE PEDAGOGICAL SEMINARY AND

JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

EDITED BY

CARL MURCHISON

JOHN E. ANDERSON
University of Minnesota

CHARLOTTE BÜHLER
Universität, Wien

CYRIL BURT
University of London

LEONARD CARMICHAEL
Tufts College

SANTE DE SANCTIS
R. Università di Roma

ARNOLD GESELL
Yale University

WILLIAM HEALY
Judge Baker Foundation, Boston

BUFORD JOHNSON
The Johns Hopkins University

HAROLD E. JONES
University of California

TRUMAN L. KELLEY
Harvard University

K. S. LASHLEY
Harvard University

A. R. LURIA
Medico-biological Institute, Moscow

HENRI PIÉRON
Université de Paris

GEORGE D. STODDARD
University of Illinois

CALVIN P. STONE
Stanford University

LEWIS M. TERMAN
Stanford University

GODFREY THOMSON
University of Edinburgh

E. L. THORNDIKE
Teachers College, Columbia University

C. J. WARDEN
Columbia University

JOHN B. WATSON
New York City

HELEN THOMPSON WOOLLEY
Teachers College, Columbia University

If this space should be unstamped, this is the regular library edition. But if this space is stamped with a designating title, this is a special edition, sold under the restrictions of a bilateral contract, and may not be resold for a period of five years from date of publication.

VOLUME 71

1947

Copyright, 1947, by The Journal Press

Published quarterly by The Journal Press
Provincetown, Massachusetts, U. S. A.

AUTHOR INDEX

TABLE OF CONTENTS

The Journal of Psychology

EDITED BY

Carl Murchison

The Journal of Psychology was founded at the request of many psychologists throughout the world for the purpose of establishing a medium in which publication shall be immediate and in which other publication experiments may be carried out.

(1). The subscription price will be $7 per volume.

(2). The format of each volume will be such that each subscriber may tear down the assembled volume into its component articles.

(3). Except through the fault of the author, the lag in publication should not be more than three or four weeks.

(4). The author will receive 200 reprints of his paper, and subscriber will receive the accumulated publications bound into half volume units. The second half of each volume will contain the title page and table of contents for that volume. Each half volume unit will be mailed to the subscribers at its stated date.

(5). Each author will be charged the actual manufacturing costs of any zinco or halftone cuts.

(6). The publication charges will be as follows:

4	page	signature	$22.00
8	"	"	32.00
12	"	"	48.00
16	"	"	64.00
20	"	"	80.00
24	"	"	96.00
28	"	"	112.00
32	"	"	128.00
36	"	"	144.00
40	"	"	160.00

These charges are tentative and will be adjusted as justified by the subscription list (especially by the effect of the war in China and in Europe).

(7). The accumulated units will be mailed to subscribers quarterly: January, April, July, and October. The units may vary in size, to accommodate publication needs.

Two volumes annually. Per annum $14.00; per volume $7.00; per half volume unit $4.00. Complete sets at $7.00 per volume plus transportation.

THE JOURNAL PRESS
2 Commercial Street
Provincetown, Massachusetts
U. S. A.

$7.00 per volume
Single Numbers $4.00

QUARTERLY
Two volumes per year

September, 1947
Volume 71, First Half

Founded by G. Stanley Hall in 1891

THE PEDAGOGICAL SEMINARY AND JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

If this space should be unstamped, this is the regular library edition. But if this space is stamped with a designating title, this is a special edition, sold under the restrictions of a bilateral contract, and may not be resold for a period of five years from date of publication.

SEPTEMBER, 1947

Copyright, 1947, by The Journal Press
Provincetown, Massachusetts
Entered as second-class matter May 11, 1937, at the post-office at Provincetown, Mass., under the act of March 3, 1879

The Journal of Genetic Psychology, 1947, 71, 3-48.

CHILDREN'S AUDIOGRAMS IN RELATION TO READING ATTAINMENT: II. ANALYSIS AND INTERPRETATION*

Department of Education, University of North Carolina

SIBYL HENRY

Certain limitations should be kept in mind throughout this report. Only elementary school children participated in the study, and therefore the group was more homogeneous in age than the general school population. The study attempted to measure only one type of hearing ability, acuity, and certainly there are several other abilities with which the auditory field is concerned. Acuity was determined for 10 specific tones, and research may prove other tones of equal or greater importance for hearing speech sounds. Moreover, the sensory responses in the modality of hearing, directly dependent as they are upon the physical pressure of sound waves, may have slight relationship to the ability to translate the sensations of sound into meaning. Further, neither audiometer tests nor reading tests yield precise-unit measurements, and consequently their values are reliable only within limits. All interpretations, therefore, should be made in the light of the specific materials and methods employed.

A. AUDIOMETRIC DATA

There are several methods in use for evaluating per cent hearing loss. Carter (14) reviews 11 methods in current use. Also there are several formulae used for evaluating, from audiometric graphs, the per cent of hearing adequate for speech sounds, all of which, Carter says, are roughly empirical. The method which seems to be the most generally used is the Western Electric Method (99 and 105). The sum of the losses in decibels for the 512, 1024, and 2048 tones is multiplied by .266 for the per cent hearing loss. If frequency 2896 is included in the audiometric range, loss at this frequency is included in the calculations. Per cent loss is recorded separately for the left and right ears. Justification for determining hearing loss by this method is evidence that frequencies above 2000 level are considered secondary in importance to the frequencies below this level for hearing speech sounds. Still other methods (36) include the 4,000 frequency in computing per cent loss. At least one writer (105), believing that the higher

*Received in the Editorial Office on June 1, 1946.

NATIONAL INSTITUTE OF

frequencies are also important for understanding speech sounds, offers different formulae for determining adequate hearing. He believes that the high frequencies carry the emotional, symbolic, and intellectual meanings, and offers formulae in which losses at the high frequencies are given more weight in the calculation of the per cent loss than are given the low frequencies for subjects who wish to know their capacity for complete hearing.

For this study neither viewpoint was accepted as final. If frequencies below and including the 2,000 are adequate for the interpretation of speech, then it follows that hearing within this range is adequate for attainment in reading if there is an inter-relation between hearing and reading attainment. On the other hand, if acuity for hearing the higher frequencies is important for making fine distinctions in speech sounds, it would follow that hearing for these frequencies is of importance for learning to read—assuming again that a relationship exists between hearing acuity and reading progress.

Neither is there agreement as to the relative importance of binaural and monaural hearing for the interpretation of speech. It is frequently assumed that monaural hearing, if the matter of localization of sound is disregarded, is little less efficient than binaural hearing; and that hearing at certain frequencies in one ear is compensated for by the other ear providing loss for the same frequencies does not occur. Otologists differ in their estimates of the efficiency of one good ear as compared to two good ears from 5 to 50 per cent (14, p. 881). There does not seem to be enough agreement or scientific evidence to warrant taking the better ear as determined by percentage loss as the index to the child's hearing ability, or to warrant a composite audiogram made up of better hearing at each frequency taken from the audiograms of both ears as the index.

In addition to the lack of standardization as to how to compute the amount of hearing loss, the dividing line between the normal hearing and the hard of hearing cannot be finely drawn. The definition of the hard of hearing set forth a few years ago by the Conference of Executives of American Schools for the Deaf is "those in whom the sense of hearing, although defective, is functional with or without a hearing aid." This definition is useful in distinguishing hard of hearing and deaf—the deaf being defined by the conference as "those in whom the sense of hearing is non-functional for the ordinary purposes of life" (8, p. 124); but it is of little value in distinguishing the normal from the hard of hearing. Below what decibel value or per cent hearing loss should the child be classified as having defective hearing? Conversely, above what level should he be classified as normal? A definite answer to the question lacks scientific formulation.

TABLE 1

MEAN DECIBEL LOSS FOR LEFT AND RIGHT EARS, MALE AND FEMALE, AND TOTAL POPULATION

		Left ear		Right ear		Left ear		Right ear	
		Mean loss	*SD*	Mean loss	*SD*	Mean loss	*SD*	Mean loss	*SD*
		Tone 128				*Tone 2896*			
Male	(N=143)	5.49	±6.91	5.77	±6.95	10.24	±8.66	8.95	±8.44
Female	(N=144)	5.24	±6.25	6.46	±7.24	8.72	±8.16	8.61	±8.65
Total	(N=287)	5.37	±6.64	6.11	±7.11	9.48	±8.45	8.78	±8.55
		Tone 256				*Tone 4096*			
Male		6.68	±7.22	5.56	±6.48	10.70	±11.30	9.23	±10.55
Female		6.70	±7.36	7.19	±7.97	7.36	± 8.48	7.64	± 8.88
Total		6.69	±7.29	6.38	±7.31	9.02	±10.13	8.43	± 9.78
		Tone 512				*Tone 5792*			
Male		8.50	±7.12	7.52	±8.17	12.94	±12.09	12.27	±12.21
Female		8.09	±8.06	9.13	±8.83	8.26	±10.07	8.26	± 8.98
Total		8.29	±7.61	8.32	±8.54	10.59	±11.37	10.26	±10.90
		Tone 1024				*Tone 8192*			
Male		9.62	±7.62	8.92	±7.51	13.53	±10.93	13.74	±13.02
Female		10.31	±8.04	10.17	±8.24	10.07	±10.69	11.25	±10.58
Total		9.98	±7.84	9.55	±7.91	11.79	±10.95	12.49	±11.92
		Tone 2048				*Tone 11,584*			
Male		6.29	±6.94	5.35	±6.60	14.72	±11.66	14.86	±13.00
Female		5.87	±7.74	6.28	±8.57	11.07	±12.11	11.25	±10.84
Total		6.08	±7.35	5.82	±7.67	12.89	±12.03	13.05	±12.12

Lacking standard procedures for determining and evaluating hearing loss the first steps undertaken in this study were to determine mean hearing loss for each frequency and ear, and correlations for the left ear versus right ear scores and for the test versus re-test scores. Table 1 gives the mean decibel loss for each ear at each frequency for males, females, and total. This information studied graphically shows that the contours for the left and right ears for the total population show close agreement. Male, left and right ear means show a rather steady decrease in acuity from the low to the high tones with the exception of the 2048 tone. Increased acuity here paralleling acuity at the lowest tones is marked and holds for both ears. Female left and right ears have very similar contours. Female means for the separate ears differ from the male in the four highest frequencies. The slope of the decline for females is interrupted beginning with the 2048 frequency; losses at 2848, 4096, and 5792 are comparable, then drops at the 8 and 11 thousand frequencies.

Table 2 gives the mean losses for left and right ears combined for males and females, also standard deviations and critical ratios. Females in the study hear tones 4096, 5792, 8192, and 11,584 reliably better than the males. Female scores are reliably more variable than male scores on the 2048 tone;

TABLE 2

MALE AND FEMALE MEAN DECIBEL LOSS FOR LEFT AND RIGHT EARS COMBINED

	N	Mean	*SD*	Mean	*SD*
		Tone 128		*Tone 256*	
Male	286	5.63	±6.93	6.12	±6.56
Female	288	5.85	±6.79	6.94	±7.67
CR		.39	± .35	1.36	±1.34
		Tone 512		*Tone 1024*	
Male	286	8.01	±7.68	9.27	±7.57
Female	288	8.61	±8.47	10.24	±8.14
CR		.90	±1.65	1.49	±1.23
		Tone 2048		*Tone 2896*	
Male	286	5.82	±6.78	9.60	±8.58
Female	288	5.38	±8.17	8.66	±8.41
CR		.71	±3.15	1.32	± .33
		Tone 4096		*Tone 5792*	
Male	286	9.97	±10.96	12.60	±12.16
Female	288	7.50	± 8.10	8.26	± 9.54
CR		3.06	± 5.02	4.76	± 4.05
		Tone 8192		*Tone 11,584*	
Male	286	13.64	±12.02	14.79	±12.35
Female	288	10.66	±10.65	11.16	±11.49
CR		3.14	± 2.04	3.64	± 1.22

and the male scores are reliably more variable than the female scores on the 4096 and 5792 tones.

Data from a similar study were not at hand with which to compare the results of this study. However, lacking a better basis for comparison, the data were studied in relation to those collected in the National Health Survey (79) for the "under 15" age group of normal hearers.[1] Losses on only seven tones were available for comparison. Table 3 gives these comparisons. It is of interest to note that contours of loss for the two groups follow the same general pattern for all tones except the 1024.

TABLE 3

THE PRESENT STUDY COMPARED WITH THE NATIONAL HEALTH SURVEY, COMBINED LEFT AND RIGHT EAR LOSSES FOR MALE AND FEMALE

	Male			Female		
	N	Mean	*SD*	*N*	Mean	*SD*
			Tone 128			
Health survey	1072	4.3	±6.7	1036	4.8	±6.6
Present study	286	5.6	±6.9	288	5.9	±6.8
CR		3.1	± .71		2.5	± .59
			Tone 256			
Health survey	1072	8.2	±6.3	1036	8.5	±6.7
Present study	286	6.1	±6.9	288	6.9	±7.7
CR		4.9	±1.8		3.3	±2.8
			Tone 512			
Health survey	1072	7.6	±6.7	1036	7.9	±6.9
Present study	286	8.0	±7.7	288	8.6	±8.5
CR		.86	±2.8		1.4	±4.1
			Tone 1024			
Health survey	1072	1.8	±6.6	1036	1.2	±6.7
Present study	286	9.3	±7.6	288	10.2	±8.1
CR		15.9	±2.8		18.	±3.9
			Tone 2048			
Health survey	1072	.8	±7.3	1036	.7	±7.1
Present study	286	5.8	±6.8	288	5.38	±8.2
CR		12.	±1.6		10.	±2.9
			Tone 4096			
Health survey	1072	8.2	±11.4	1036	5.6	±8.6
Present study	286	10.0	±11.0	288	7.5	±8.1
CR		2.5	± .85		3.7	±1.3
			Tone 8192			
Health survey	1072	11.0	±13.6	1036	7.1	±11.0
Present study	286	13.6	±12.0	288	10.7	±10.7
CR		3.5	± 2.7		5.3	± .69

[1]Normal hearers in the surveys were defined as the group reporting no noticeable defect and no known defect among members of their families.

Mean losses at the 128, 1024, 2048, and 8192 frequencies were reliably greater for boys in the present study than for those in the National Survey, and reliably less at the 256 frequency. Girls in the present study had reliably more loss than girls in the Health Survey on the 1024, 2048, 2096, and 8192 tones, and reliably less on the 256. For no tone did the boys' scores show a difference in variability as reliable as 3 sigma. Girls' scores in the Health Survey, however, were reliably less variable than those of the girls in the present study for the 512 and 1024 tones. Apparently the amount of variation in hearing acuity for children who are classified as normal hearers is almost as great as it is for an unselected group of children.

Certain speculations arise from both sets of audiometric data. Is normal hearing, the *0* level, as established on the basis of normal adult ears,[2] too high a reference level for determining children's acuity, especially for the high frequencies? The high frequencies are supposed to require closer concentration for success than the low, and this quite logically might create an apparent rather than real loss. A further reason for questioning the suitability of the accepted norms as a basis for determining normal hearing for children is the fact that serious aural diseases have their highest incidence during childhood and the hearing impairments accompanying them may contribute materially toward raising the stimulus thresholds above those of the normal adult.

Why tone 2048 should be keener than other tones in the central tone range in both sets of data is problematic, certainly. In addition to the keenness of the 2048 tone the Health Survey found acuity for the 1024 tone approaching that of the 2048 among the normal hearers, male and female, for each decade of life. For the groups reporting certain stages of impairment—conversation, auditorium speeches, telephone, etc.—there was not this relative keenness for either tone. This fact suggests that loss at these frequencies caused the individual to be aware of a loss in hearing acuity. This explanation seems logical since the frequencies in this region are in the heart of the speech range and are also in the region to which the ear is the most sensitive. The present study found hearing for the 2048 tone keener than for the surrounding tones but did not find the relative keenness for the 1024 tone.[3] Perhaps keenness for 1024 tone found in the Health Survey was incidental to the 2048 keenness. Perhaps differences in intensity control of the one tone in the instruments might account for the discrepancy since the

---

[2]Adults used for establishing normal hearing in the Health Survey reported no noticeable difficulty, and subsequent otological examinations showed no pathology.
[3]A statistical comparison of loss on the two tones was not made, however.

greatest departure in the two studies is found here. Or perhaps some persistent extraneous sound of a frequency near the 1024 tone, such as reported by Kobrak (59), masked the tone consistently during the testing for this study. All are possibilities.

No attempt is made in this study to indicate a dividing line between normal and impaired hearing. The mean loss and the amount of variation for the 10 frequency scores have been incorporated in the report mainly for the purpose of calling attention to the similarity of the losses found by the Health Survey for a selected group of children tested in a sound-insulated booth and those found for an unselected group tested in a "quiet room"; also to raise specifically the question of the adequacy of existing norms for determining hearing loss for children; and further, to furnish other investigators with more detailed information regarding children's hearing abilities than is available at the present.

Table 4 gives the correlation coefficients[4] for the left ear versus the right ear for the first test. The correlations show a positive relationship for every tone, with probable errors denoting a highly significant relationship. The correlations are probably as high as one would expect to find for the two ears, but they certainly are not high enough to warrant using the loss scores for one ear alone as an adequate measure for assigning hearing losses.

TABLE 4

CORRELATION COEFFICIENTS FOR LEFT EAR VERSUS RIGHT EAR, FIRST TEST, $N=295$

Tone	r	PE	Tone	r	PE
128	.360	±.036	2896	.484	±.030
256	.487	±.030	4096	.506	±.029
512	.520	±.029	5792	.542	±.028
1024	.460	±.031	8192	.557	±.027
2048	.584	±.026	11,584	.548	±.027

Table 5 gives the correlations and reliability coefficients, computed by the Spearman Brown formula,[5] for the test and retest scores. The degree of relationship between the test and retest for the two ears and the degree of reliability for the individual tone tests, with the added weight of the preliminary analysis which showed a decreased efficiency on the second test, seemed to justify the use of the first test alone as the basis for further study of hearing acuity.

The decision to use only one test narrowed the field of investigation con-

[4]All correlation coefficients given in the paper were computed by the Pearson Product moment formula.

[5]The reliability coefficient indicates the degree to which an average of two readings could be duplicated on a retest.

TABLE 5
CORRELATIONS BETWEEN TEST AND RETEST, LEFT AND RIGHT EARS

Left ear N=262			Right ear N=262		
Tone	r	Coefficient of reliability	Tone	r	Coefficient of reliability
128	.581	.735	128	.564	.721
256	.654	.791	256	.636	.778
512	.641	.781	512	.664	.798
1024	.592	.744	1024	.610	.758
2048	.677	.807	2048	.670	.802
2896	.726	.841	2896	.683	.812
4096	.800	.889	4096	.705	.827
5792	.797	.887	5792	.778	.875
8192	.788	.881	8192	.781	.877
11,584	.845	.916	11,584	.820	.901

siderably, but the data still involved 5900 tone tests. So a factor analysis[6] of one ear was undertaken to discover if there were tones that could be eliminated from the data without destroying any of the original significance.[7] Thurstone's centroid method (51, ch. XIV) was applied to the intercorrelation of the 10 scores for the left ear to obtain a factor matrix. Table 6

TABLE 6
INTERCORRELATION OF 10 TONES FOR LEFT EAR

Tone	128	256	512	1024	2048	2896	4096	5792	8192	11,584
128		.740	.506	.472	.406	.390	.325	.225	.346	.317
256	.740		.656	.590	.462	.416	.355	.352	.392	.355
512	.506	.656		.642	.428	.349	.343	.394	.448	.359
1024	.472	.590	.642		.567	.468	.413	.410	.479	.364
2048	.406	.462	.428	.567		.684	.562	.469	.433	.299
2896	.390	.416	.349	.468	.684		.653	.511	.474	.300
4096	.325	.355	.343	.413	.562	.653		.676	.506	.398
5792	.225	.352	.394	.410	.469	.511	.676		.672	.521
8192	.346	.394	.448	.479	.433	.474	.506	.672		.659
11,584	.317	.355	.359	.364	.299	.300	.398	.521	.659	

[6]Dr. R. J. Wherry of the Department of Psychology, University of North Carolina, did the factor analysis.

[7]Factor analysis has been employed to treat various auditory functions. One investigator factored the scores made on a battery of 10 music tests. The battery included the usual types of tests for musical ability, as pitch discrimination, tonal memory, intensity, consonance, etc. He found three factors which he called *sensitivity*, *memory*, and *retentivity* (56). Later the same investigator reported a factor analysis of hearing acuity as related to complex social situations. Auditory acuity was determined by an audiometer. Auditory behavior in complex social situations was tested by using several masking techniques as buzzers and simultaneous voice sounds while the subject was trying to listen to speech; also by introducing defects into the articulation of the vocal sound itself, as changing rates of speech, and too rapid sequence of sounds. He concluded from the analysis that the "conventional auditory tests have little predictive value for the auditory behavior in more complex social situations for normally hearing subjects" (57).

shows the intercorrelation of the 10 scores. The highest intercorrelation coefficient in each column of the intercorrelation table was placed in the diagonal as the assumed communality. Signs were reflected before the removal of each factor in order that the sum of each column should exceed the value of its diagonal entry. Three factors were removed from the matrix. The reference axes of the factors were rotated orthogonally, two factors at a time. New loadings were computed after each rotation. The unrotated factor loadings are shown in Table 7. The final loadings after three rotations are shown in Table 8.

TABLE 7
UNROTATED FACTOR LOADINGS

	I	II	III
128	.64	—.43	.20
256	.73	—.49	.08
512	.69	—.36	—.20
1024	.73	—.23	—.09
2048	.72	.09	—.27
2896	.71	.23	—.38
4096	.70	.35	—.19
5792	.70	.40	.15
8192	.73	.27	.35
11,581	.61	.17	.33

TABLE 8
ROTATED FACTOR LOADINGS

	Low	Medium	High
128	.70	.00	.17
256	.85	.18	.17
512	.69	.42	.05
1024	.62	.39	.21
2048	.35	.63	.28
2896	.22	.75	.29
4096	.15	.63	.46
5792	.16	.38	.71
8192	.29	.21	.78
11,581	.30	.13	.64

A low-tone, a medium-tone, and a high-tone factor are indicated by the analysis. Each factor indicates the operation of some systematically functioning cause or set of causes. To an extent the causes operating to produce the three variables occur independently of each other, although as is to be expected of measures of auditory acuity, with one exception none of the tones measuring predominantly one of the three factors is entirely lacking in either of the other factor loadings.

The value of discovering the three most significant regions for evaluating

hearing loss is immediately apparent. Tones of significance in the low frequency region can be combined into a low tone variable; medium frequency and high frequency variables can be resolved in like manner, yielding a set of three variables more fundamental in nature than the original set of variables.

This by no means should be interpreted to mean that audiometric data can always be resolved into three significant factors. Factors are influenced by many phenomena. Factors other than low, medium, and high-tone might be isolated if a different set of tones was used for the test, or a different method for designating threshold used, or if the sampling involved a different age or economic group. It does mean that the hearing loss discovered in these particular data can be studied in low, medium, and high-tone categories.

Factor scores for the three tone regions were arrived at by combining loss at the two lowest tones, 128 and 256, both ears, for a low-tone factor score; by combining the loss at 2048 and 2896 frequencies, both ears, for a medium-tone factor score; and by combining the loss at the 8,192 and 11,584 frequencies, both ears, for a high-tone factor score. The low-tone factor was arbitrarily called Factor *A*, the medium tone Factor *B*, and the high tone Factor *C*.[6]

While the factor analysis was originally made only of the scores of one ear, the left one, the factor scores *A*, *B*, and *C* included the loss for the corresponding tones on the right ear. As was shown in Table 2 the correlations between left ear and right ear scores appeared too low to consider loss in one ear alone as the value for hearing acuity. In combining the losses for the two ears it was assumed that the factor pattern for the right ear would approximate that for the left. The Reliability Coefficients for these three factor scores were found to be: *A*, .91; *B*, .92, and *C*, .93.

A subsequent factor analysis of the right ear scores showed a low, a medium, and a high tone factor, as was assumed, although a one-tone shift in the medium-tone factor. Tables 9, 10, 11 show the intercorrelations of the 10 tones, the unrotated factor loadings, and the rotated factor loadings for the right ear scores.

---

[6]It is of interest in this connection that an otologist recently, as a result of his own experience, calls attention to the fact that regression is linear for the 64, 128, 256, and 512 frequencies, and that acuity for any one will have approximately the same value as the four combined; also that the 1024 and 2000 have comparable predictive value; that above the 2000 frequency the correlation between pairs of tones is lower, dispersion greater, and regression more curvilinear. For these reasons he suggests the use of one tone in each of the 500 and 2000 frequency regions, and at least two above the 2048 cycle, for screening or clinical use (7).

TABLE 9
INTERCORRELATIONS FOR TEN TONES FOR RIGHT EAR

Tone	128	256	512	1024	2048	2896	4096	5792	8192	11,584
128		.720	.625	.568	.597	.523	.477	.294	.406	.360
256	.720		.720	.591	.545	.458	.435	.280	.391	.321
512	.625	.720		.648	.623	.519	.505	.339	.415	.350
1024	.568	.591	.648		.609	.529	.452	.353	.479	.310
2048	.597	.545	.623	.609		.683	.544	.366	.450	.292
2896	.523	.458	.519	.529	.683		.647	.395	.463	.332
4096	.477	.435	.505	.452	.544	.647		.562	.541	.356
5792	.294	.280	.339	.353	.366	.395	.562		.667	.560
8192	.406	.391	.415	.479	.450	.463	.541	.662		.670
11,584	.360	.321	.350	.310	.292	.332	.356	.560	.670	

TABLE 10
UNROTATED FACTOR LOADINGS

	Right ear		
	I	II	III
128	.74	—.30	—.14
256	.73	—.34	—.27
512	.77	—.30	—.12
1024	.73	—.24	—.06
2048	.76	—.26	.24
2896	.73	—.08	.34
4096	.73	.11	—.32
5792	.63	.50	—.07
8192	.72	.44	.12
11,581	.59	.43	.27

TABLE 11
ROTATED FACTOR LOADINGS

	Right ear		
	Low	Medium	High
128	.75	.13	.29
256	.78	.00	.32
512	.77	.16	.28
1024	.68	.21	.27
2048	.70	.45	.09
2896	.34	.58	.14
4096	.21	.63	.27
5792	.09	.55	.57
8192	.21	.43	.70
11,581	.14	.25	.74

Table 12 gives the mean *A*, *B*, and *C* scores for male, female, and total population, together with the standard deviations. An examination of the mean and standard deviation differences for *A*, *B*, and *C* scores reveal the following: comparing *A* and *B* mean losses, there is 5.56 decibels greater

TABLE 12
A, *B*, AND *C* MEAN LOSS FOR MALE, FEMALE AND TOTAL POPULATION

	Male (N=143)		Female (N=144)		Total (N=287)	
	Mean loss	*SD*	Mean loss	*SD*	Mean loss	*SD*
A	23.53	±21.06	25.63	±24.42	24.58	±22.83
B	30.77	±23.63	29.51	±28.57	30.14	±26.23
C	56.12	±37.35	43.68	±37.81	49.88	±38.09

loss at *B* than at *A*. The critical ratio[9] of the differences in favor of *A* loss being less than *B* loss is 2.71, well within Fisher's 1 per cent limit; the critical ratio of the standard deviations in favor of *A* variability being less than *B* variability is 2.34, within Fisher's 5 per cent limit (51, ch. VIII); comparing *A* and *C* mean loss, the mean loss at *C* is 25.30 decibels greater than at *A*. There is a virtual certainty that *C* loss will be greater than *A* loss (CR=9.65) and that *C* scores will be more variable than *A* scores (CR=8.23); comparing *B* and *C* mean differences (19.74 decibels) there is again virtual certainty that *C* loss will always be greater than *B* loss (CR=7.23) and that *C* scores will be more variable than *B* scores (CR=6.14).

Males hear low tones, *A* scores, better by 2.10 decibels than females; however, the *CR* is only .78, indicating that the slight superiority for males is probably due entirely to chance. There is less variation in the male *A* scores than in female *A* scores. The *CR* of 1.76, however, indicates little more than a chance difference. Females have better hearing than the males at the medium tones, *B*, by 1.26 decibels; the *CR* is .41, showing that the difference is probably due to chance. *B* scores for males are an average of 4.94 decibels less variable than females; the *CR* of 2.26 denotes reliability within the 5 per cent limit. Mean high-tone, *C*, loss is 12.44 decibels greater for males than females, with a *CR* of 2.80 which indicates that the difference could be due to chance less than 1 per cent of the time. The difference in variability at *C* for the two sexes is negligible. The *CR* of .15 indicates that the variability is pretty certain to be as great for one sex as the other.

Comparing the relative loss at low and medium tones, low and high tones, and medium and high tones for males and females: for males the mean difference between *A* and *B* scores shows more loss at *B* than *A*, with a *CR* of 2.73, well within the 1 per cent limit; *B* is more variable than *A* but un-

[9]Critical ratio formula used:

$$\frac{M_1 - M_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}}$$

reliably so ($CR=1.37$). Female mean loss at B is also greater than at A but less reliably so than the male difference ($CR=1.24$ for females). Their variability at B as compared to A is greater, $CR=1.87$. Comparing loss at A in relation to C, the mean loss for males is 32.59 decibels greater at C than at A, $CR=9.07$, variability for C scores is greater than for A with a CR of 6.44. Female loss at C as compared to A has a greater mean loss by 18.05 decibels, $CR=4.81$. Also their C scores are more variable than A, $CR=5.45$. Comparing B and C male scores, the mean hearing loss is 25.35 decibels greater at C than B, $CR=6.86$, and C scores are more variable than B scores, $CR=5.26$. Female C scores are 14.17 decibels greater than their B scores, $CR=3.58$; also there is more variability at C than at B with a CR of 3.31.

Summarizing these tone and sex differences: There is virtual certainty that C loss will be greater and more variable than A or B loss. There is not the same degree of certainty that B loss will be greater than A loss, although the mean difference approaches reliability ($CR=2.71$) as does the sigma difference ($CR=2.34$). There is no reliable sex difference in low-tone or medium-tones scores; however, A and B scores are less variable among the boys ($CR=1.76$ and 2.26 respectively) than among the girls. The CR of 2.26 is within the 5 per cent limit. C scores show no difference in variability for the sexes, but girls' hearing is significantly better than boys' for C, high tones, with a critical ratio of 2.80.

The high incidence of high-tone loss in this study is in line with other recent studies. Traditionally, high-tone loss has been associated with advancing age, but several studies within the past few years report "old-age audiograms" among young children (15 and 22). Also the superiority of female hearing for the high tones found in the present study has been reported several times and is pretty generally accepted (15, 11, and 72). Male superiority for hearing low tones, however, found by these investigators was not found in this study. This might be due to the fact than in the present investigation only two tones, the 128 and the 256, were designated as the low tones while other reports have considered all of the tones below 2,000 as low tones. From the point of view adopted in this study—that the 128 and the 256 are the significant tones—it is concluded that for the population involved there is no reliable sex difference in acuity for low tones.

Audiograms for three age groups were compared in an attempt to find if hearing loss differed according to age for the children in the particular population studied. The 5, 6, 7, and 8 year-olds, 67 in number, constituted the youngest group; the 9, 10, and 11 year-olds, 146 in number, the middle

group; and the 12 through 17 year-olds, 75 in number, the oldest group. Table 13 shows the mean decibel loss and variability for these three age levels. On the *A* and *C* scores the oldest have less mean loss than the youngest, but the differences are not significant; neither is the amount of variability for either tone region more than a chance difference for the two age levels. For *B* tones the oldest group has slightly more loss than the youngest and slightly less variability, but the differences are apparently due almost entirely to chance. The oldest females have more mean loss than the youngest females on the *A* and *B* tones, and less on the *C* tones, but these differences do not approach reliability, neither do the slight differences in variability. The *A, B,* and *C* loss is greater for the youngest males than for the oldest males, but the differences can be attributed to chance factors as can the amounts of variability. At the 6, 7, and 8 year level the males have more *A, B,* and *C* loss than females of the same age level, but the differences are negligible. At the 12-17 year level females have more loss than the males for the *A* and *B* tones, and less for the *C* tone. In no instance is the mean or standard deviation difference significant for the oldest and youngest in the study.

A rather intensive analysis was made of *A, B,* and *C* loss for the 9, 10, 11 year-olds, thus eliminating both extremes in age. It was found that the children of this age group hear slightly worse than the oldest group and slightly better than the youngest on the *A* and *C* tones, but the differences are not significant. On *B* tones they hear slightly worse than the youngest or the oldest.

The relative differences in mean loss and variability for the boys in the 9, 10, and 11 year group for *high and low* tones, *middle and high* tones, and *middle and low* tones is comparable in each instance to the differences for the total population of boys. Differences for the girls in this age level, 9, 10, and 11 year-olds, are comparable to the total girls on the relative *A* and *B* loss only; the total girls are reasonably certain to have more *C* loss than *A* loss (CR=4.81), and more *C* than *B* loss (CR=3.58); but it cannot be said with the same degree of certainty that the 9, 10, and 11 year girls will have this relative *C and A* (CR 2.77) and *C and B* (CR 2.23) loss. For the total girls *C* is practically certain to be more variable than *A* or *B* (CR 5.45 and 3.31); but for the 9, 10, 11 year girls this degree of positiveness is lacking. It is found that girls in this age group have better *C* hearing than boys, CR of 2.88. This is a slightly higher reliability than for the total male and female population. At *B* the mean difference for boys and girls in this age group is negligible. Girls have more variable *B* scores

TABLE 13

A, *B*, and *C* Loss by Age Levels

	Male			Female			Total		
	N	Mean	*SD*	*N*	Mean	*SD*	*N*	Mean	*SD*
				A Loss					
6-7-8 year-olds	31	29.68	±22.18	35	25.71	±17.16	66	27.58	±19.78
9-10-11 year-olds	64	22.34	±20.33	82	25.12	±28.54	146	23.90	±25.31
12-17 year-olds	48	21.15	±20.52	27	27.04	±17.91	75	23.27	±19.82
				B Loss					
6-7-8 year-olds	31	32.53	±22.86	35	29.57	±27.07	66	30.99	±24.31
9-10-11 year-olds	64	29.69	±25.62	82	27.50	±31.83	146	28.46	±29.29
12-17 year-olds	48	31.04	±21.16	27	35.56	±19.69	75	32.67	±20.76
				C Loss					
6-7-8 year-olds	31	61.61	±37.25	35	53.71	±35.98	66	57.42	±36.80
9-10-11 year-olds	64	58.91	±41.06	82	39.76	±38.32	146	48.15	±40.67
12-17 year-olds	48	48.85	±30.47	27	42.59	±36.19	75	46.60	±32.78

than boys, but the *CR* is only 1.84. This is a less reliable difference in variation than is shown for the total population of boys versus girls (*CR* 2.26). The difference in *A* scores for boys and girls in this age group is negligible; however, the girls' *A* scores are more variable than the boys' *A* scores, critical ratio of 2.87, while the critical ratio of the difference in variability for the total boys versus girls is only 1.76.

The main points of interest in the audiometric data that have been presented in this section are: (*a*) children show marked audiogram variability; (*b*) audiograms for many children follow those traditionally considered characteristic of advancing age; (*c*) there are three fundamental tone areas—low tone, middle tone, and high tone; (*d*) there are highly significant differences between low-tone and high-tone loss and between middle-tone and high-tone loss in both means and variability. There is virtual certainty that loss and variability will be greater for high tones than for either low or middle tones; (*e*) there are no consistent sex or age differences when comparing relative low and high, medium and high, and low and medium tone losses; (*f*) girls' mean hearing for the high tones is reliably keener than that of the boys.

B. Audiograms and Reading Abilities

1. *Achievement Test Data*

For the purpose of studying audiograms of children with different levels of reading attainment as measured by achievement tests, the 287 children were divided into three reading attainment groups: below normal readers with reading quotients ranging from 52-89, 62 cases; normal readers with *RQ*'s ranging from 90-109, 127 cases; and above normal readers with *RQ*'s ranging from 110-145, 98 cases. Table 14 shows the mean *A*, *B*, and *C* loss and the standard deviations for the three reading groups.

TABLE 14
A, *B*, and *C* Loss for the Poorest, the Average, and the Best Readers

RQ	*N*	*A* loss		*B* loss		*C* loss	
		Mean	*SD*	Mean	*SD*	Mean	*SD*
52- 89	62	27.18	±31.25	37.74	±39.33	64.35	±44.35
90-109	127	24.88	±19.87	30.04	±20.87	48.98	±36.02
110-145	98	21.84	±18.36	25.66	±22.75	40.71	±32.55

Hearing loss follows the same pattern for each of the three reading groups. The best readers are characterized by less loss at the low, middle, and high frequencies than either the normal or below normal readers. Normal readers have more loss than the superior readers, and less than the poorest. Varia-

tions in scores for the best and normal readers is quite similar. Greater variation in score than for the normal or superior readers is marked for the below normal readers at each frequency. The difference in mean *A* loss is 5.34 decibels greater for the poorest than for the best readers. The critical ratio (1.22) of this difference does not signify a reliable difference. The variability in the scores, however, is reliably less for the best readers. The critical ratio is 4.16 which indicates that the differences in variability on the low-tone scores for the best and poorest readers cannot be due to chance.

The mean *B* score loss is 12.08 decibels greater for the poorest readers than for the best readers. The critical ratio of the difference is 2.20. This shows that the difference would not be due to chance over 5 per cent of the time and is therefore indicative of a slight difference although not great enough for assuming certainty that the poorest readers will always have more middle-tone loss than the best readers. It can be said with virtual certainty, however, that the poorest readers will vary more in *B* tone scores than the best readers. The *CR* of this difference is 4.26.

The poorest readers average 23.65 decibels greater loss for high tones, *C*, than the superior readers. The *CR* of the difference is 3.62, a highly significant difference; therefore the lower *C* scores for the poorest readers is not due to chance. The difference in variation (*CR* of 2.56) for the two groups is not as highly reliable as the difference in means although it is well within the 5 per cent limit and certainly indicates a tendency for the best readers to be more homogeneous on high-tone scores than the poorest readers.

This ostensible association between success in reading and high-tone acuity suggested that the relationship should be explored as far as the data permitted, hence several types of analyses were attempted. The first was a tabulation of the reading quotients for the children with the least *C* loss and those with the most *C* loss. There were 73 children whose total *C* score was not greater than 20 decibels. Since four frequency scores were combined for the *C* score this meant that no child in this group averaged more than a 5 decibel loss for each of the four frequency scores. This represents extremely acute hearing for the high frequencies. There were 73 cases with *C* scores ranging from 70 to 260 decibels[10] which, needless to say, represents scores for the children with the most *C* loss. Table 15 gives the mean hearing loss and mean reading quotients with standard deviations for these two groups.

[10]Seventy decibels at the 8192 frequency, and 60 decibels at the 11,584 frequency are the maximum intensity limits on the audiometer used. The one child, therefore, with *C* loss of 260 had no hearing for these tones as measured by the instrument.

TABLE 15

MEAN LOSS AND MEAN READING QUOTIENTS FOR THE WORST C AND THE BEST C HEARERS

C scores		Decibel loss Mean	Decibel loss SD	Reading quotients Mean	Reading quotients SD
0- 20	$N=73$	13.73	$\pm$ 6.30	108.30	$\pm$15.40
70-260	$N=73$	103.08	$\pm$32.21	97.68	$\pm$17.60

The difference in mean reading quotients for these extremely good and extremely poor hearers is only 10.62 *RQ* points—in no wise proportionate to the mean difference in C scores—but the critical ratio of the difference is 3.80 which signifies that the difference that does exist is highly significant.

In the 0-20 C group there are only 8 children, 1+ per cent of the 73, whose *RQ*'s are below 90; there are 36 children, 49+ per cent, with *RQ*'s 110 or above. In the 70-260 group there are 25 children, or 34+ per cent, whose *RQ*'s are below 90; and 18, or 24+ per cent, whose *RQ*'s are 110 or above. The critical ratio of the difference in the per cents[11] of children in the best C score group with *RQ*'s below 90 and those with *RQ*'s above 110 is 7.04. The critical ratio of the different percentages of children in the 0-20 group and 70-260 group that will attain above normal reading quotients is 3.10. On the other hand the difference in percentages of children in the 70-260 that will fall below normal in reading and above normal in reading is not statistically reliable. Apparently this might be interpreted to mean that for the child in 0-20 hearing group the chances are reliably better for him to be an excellent reader than a poor reader; that his chances of being an excellent reader are reliably better than are the chances of a child in the 70-260 group. However, for the child in the 70-260 hearing group the chances for him to attain excellent reading are approximately equal to the chances for him to fall below normal in reading.

Reasons for totaling loss for both ears for the final low, medium, and high-tone scores were given earlier in the paper: the discrepancy in opinions and the lack of evidence as to the relative importance of monaural and binaural hearing and inadequate knowledge as to what extent good hearing at one frequency in one ear can compensate for loss at that frequency in the other ear. There is a bit of recent evidence to support the idea that pitch may be a function of binaural interaction (97). There is also the opinion

[11] $\text{Sigma } p = \sqrt{\dfrac{pq}{N}}$

$$\text{Sigma } Dp = \sqrt{\frac{p_1 q_1}{N_1} + \frac{p_2 q_2}{N_2}}$$

that binaural fitting of hearing aids is more satisfactory than monaural fitting (6). There is also a slight amount of indication that learning may be associated with binaural hearing: Madden (65) found more retardation among children with only one good ear than among children with two good ears. It logically follows that binaural hearing may influence success in reading. The problem was approached in the present study by studying "best spots" and "worst spots" at *C* in relation to reading quotient. It will be remembered that four scores were summed for the *C* score. The "worst spot" would be that score of the four for either left or right ear or for either the 8192 or 11,584 tone, that had the largest numerical value. In like manner, the "best spot" was represented by the score of the four that had the least numerical value.

There were 92 children with a "worst spot" at *C* not greater than 10 decibels. Their "worst spots" ranged from 0 to 10. There were 67 children whose "worst spot" scores ranged from 30 to 70. Reading quotient means were computed for these two groups having such extremes in "worst spot" scores. Table 16 shows the results.

TABLE 16

MEAN READING QUOTIENTS FOR CHILDREN WITH THE BEST AND THE POOREST "WORST SPOT" *C* SCORES

"Worst spot" (Decibel)		Mean *RQ*	*SD*
0-10	(N=92)	106.57	±16.92
30-70	(N=67)	97.22	±17.42

Again, the mean differences in reading quotients is not in proportion to the difference in "worst spot" scores. The difference of 9.35 *RQ* points, however, is a statistically significant difference. The critical ratio is 3.38, and indicates that children having only a slight amount of loss at either high tone for either ear will have higher *RQ*'s than will children having a great deal of loss at either of the tones for either ear.

Table 17 shows the mean "worst spot" at *C* for the lowest and highest reading groups. Table 18 shows the mean "best spot" for the same groups.

TABLE 17

MEAN "WORST SPOT" LOSS AT *C* FOR THE POOREST AND BEST READERS

RQ's		Mean decibel loss	*SD*
52- 89	N=62	25.09	±14.16
110-145	N=98	16.87	±11.88

TABLE 18
MEAN "BEST SPOT" LOSS AT *C* FOR THE POOREST AND BEST READERS

RQ's		Mean decibel loss	*SD*
52- 89	$N=62$	8.31	±10.35
110-145	$N=98$	4.59	± 6.38

The difference in mean "worst spot" loss for the poorest readers is 8.22 decibels greater than for the best readers. The *CR* of the difference is 3.80, indicating that among the poorest readers the "worst spot" at *C* is reliably worse than the "worst spot" among the best readers.

The mean "best spot" score for the poorest readers is 3.72 decibels greater than for the best readers. The critical ratio is 2.53 which is well within the 5 per cent reliability, but too low to conclude with certainty that the "best spot" at *C* will always differentiate best and poorest readers. These tabulations of "worst spot" and "best spot" lead to the conclusion that the "worst spot" bears a closer relationship to reading attainment than does the "best spot." This in turn leads one to doubt that unilateral or bilateral tone loss is functionally compensated for to an appreciable extent. A reason for this apparent lack of compensation is, of necessity, merely speculative. However, since many of the speech sounds which require high-frequency acuity for complete hearing carry so little pressure power there is the possibility that keen hearing, in both ears and throughout the high-frequency range involved, is of importance for fine discriminations.

These reliable differences between reading attainment for children having keen hearing for the high tones and children having very poor hearing for the high tones, and the reliable differences in high tone hearing for the poorest readers and best readers, led to a comparison of the normal readers *C* loss with that of the best and poorest readers. The mean *C* loss for normal readers, *RQ*'s 90-110, is 8.25 decibels greater than mean *C* loss for the best readers. The critical ratio of the difference is 1.81 which is too low to differentiate the average and best readers. The mean *C* score for the normal readers is 15.37 decibels better than the mean *C* score for the poorest readers. The critical ratio is 2.36, which is not a highly significant difference, but according to Fisher's fiducial limits is within the 5 per cent limit for the population concerned and therefore indicative of differentiation.

The internal consistency of the relationship between high-tone loss and reading attainment score is indicated by the fact that the correlation between *C* score and *RQ* for the entire population is $-.223 \pm .057$[12] with a critical

[12]Standard deviation of r:

$$\frac{1-r^2}{\sqrt{n-1}}$$

ratio of 3.94. While a correlation of —.223 of itself signifies only a slight relationship, the critical ratio indicates that the relationship that does exist is of statistical significance.

B tone loss did not reliably differentiate the best and poorest readers. The critical ratio of 2.20 (5 per cent limit) for the mean decibel difference does, however, indicate a trend toward a relationship. For this reason the mean "worst" and "best" *B* spots were computed for the lowest and highest *RQ* groups. Tables 19 and 20 give the results.

TABLE 19
MEAN "WORST SPOT" LOSS AT *B* FOR BEST AND POOREST READERS

RQ		Mean decibel loss	*SD*
52- 89	$N=62$	14.92	± 12.65
110-145	$N=98$	10.97	$\pm$ 7.22

TABLE 20
MEAN "BEST SPOT" LOSS AT *B* FOR BEST AND POOREST READERS

RQ		Mean decibel loss	*SD*
52- 89	$N=62$	4.11	± 8.50
110-145	$N=98$	2.60	± 3.96

The mean decibel difference for *B* "worst spot" scores for the best and poorest readers is 3.95, *CR* of 2.34. This is well within the 5 per cent limit, but not high enough for assurity that the "worst spot" for the poorest readers will always show a greater loss than for the best readers.

The mean decibel difference for the "best spot" at *B* for the best and poorest readers is 1.51 with a critical ratio of 1.31. This difference is too slight to be of predicative value. As with *C* scores the "worst spot" at *B* is apparently more closely associated with reading attainment than is the "best spot."

This tendency toward an association between middle-tone loss and reading attainment is borne out by the correlation of *B* scores versus *RQ*'s for the total population. The coefficient of correlation is $-0.200\pm.057$,[13] and the critical ratio is 3.50. The high *CR* denotes that the slight relationship that exists is real. Comparisons of extreme reading cases however failed as did the "worst spot" tabulation to find *B* loss significantly differentiating the best and poorest readers.

Differences in *A* scores for the lowest and highest reading groups are

[13]Standard deviation of *r*.

apparently due to chance. The correlation between *A* scores and *RQ* for the entire population bears this out. The correlation is $-.093 \pm .059$ with a critical ratio of 1.60.

Summarizing the findings relative to high, middle, and low-tone loss in relation to reading attainment: there seemingly is only a chance association between low tone, *A*, loss and reading attainment. Middle tone, *B* loss bears more relationship to reading attainment than does *A* loss, but the differences in middle-tone scores are indicative rather than positive. High tone, *C* loss, has a statistically reliable association with reading attainment. Reading quotients are higher for best hearers than for poorest hearers; also high-tone loss is greater for poorest readers than for best readers. The association between high-tone loss and reading attainment is consistent, if slight, for the entire population. *C* loss for normal readers is more nearly comparable with *C* loss for superior readers than it is with *C* loss for poorest readers.

The poorest readers are reliably more variable in low-tone and middle-tone scores than are the best readers; their variability for high-tone scores is indicative rather than positive. There is a closer relationship between "worst spot" and reading attainment than between "best spot" and reading attainment, suggesting that good bilateral as well as good unilateral hearing accompanies success in reading. This relationship is more reliable for the high tones than it is for the middle tones.

Since the audiometric data showed that males had more high-tone loss than females, reading quotients were studied for possible sex differences relating to high-tone scores. Of the 98 children in the highest reading group (Table 14) 70 are girls and 28 are boys. The girls' mean *C* score is 15.50 decibels better than the boys' scores with a critical ratio of 2.06, which is within the 5 per cent limit and indicative of some difference in high tone loss for the sexes in the best reading group. Of the poorest readers (*RQ* 52-89), 46 of the 62 children are boys. The mean *C* loss for the girls in this group is 11.40 decibels greater than for the boys in the group, but the critical ratio suggests that the difference is due to chance.

The percentages of males and females in the poorest, average, and best reading groups are shown in Table 21.

TABLE 21
PER CENTS OF MALES AND FEMALES IN THE POOREST, AVERAGE AND BEST READING GROUPS

	Male			Female			
RQ's	*N*	Per cent	*SD*	*N*	Per cent	*SD*	*CR*
52- 89	46	74.20	±5.56	16	25.80	±5.56	6.16
90-109	69	54.33		58	45.67		
110-145	28	28.57	±4.56	70	71.43	±4.56	6.64

The differences in per cents for best and poorest readers are reliably in favor of more girls than boys being in the best reading group (*CR* 6.64); and of more boys than girls being in the poorest reading group (*CR* 6.16). Chances are also reliably in favor of a greater per cent of boys being in the lowest reading group than are in the highest reading group (*CR* 6.35); and of more girls being in the highest reading group than are in the lowest group (*CR* 6.35).

Table 15 presented mean reading quotients for the best and poorest *C* hearers. While the mean differences in *RQ* points for the two groups was not large, the critical ratio of the differences, 3.80, indicated a highly reliable relationship between reading achievement and high-tone acuity. Of the 73 keenest hearers 25 are males and 48 are females. In the group of poorest hearers the numbers are reversed, with 25 females and 48 males. Table 22

TABLE 22
PER CENTS OF MALES AND FEMALES IN BEST AND POOREST *C* HEARING GROUPS

C loss	Per cent male	*SD*	Per cent female	*SD*	*CR*
0- 20	34.24	±5.55	65.76	±5.55	4.01
70-260	65.76	±5.55	34.24	±5.55	4.01

gives the percentages of males and females in the two groups. The high critical ratios show virtual certainty that larger per cents of girls than of boys will have keen *C* hearing, and that larger per cents of boys than of girls will have poor *C* hearing.

Table 16 presented mean reading quotients for children with worst spots at *C* from 0-10 and mean reading quotients for those with worst sports at *C* from 30-70. Again difference in mean *RQ*'s was not large for the two groups, but the difference was highly reliable, *CR* 3.38. Comparing the per cents of males and females having "worst spots" at *C* from 0-10 with those having "worst spots" from 30-70, again there is a highly reliable difference between the percentages of boys and girls in the 0-10 and 30-70 group. In the 0-10 group, 35.87±5.00 per cent are boys; in the 30-70 group 70.15±5.59 per cent are boys. The critical ratio of the per cent difference is 4.57. The chances are significantly in favor of a higher per cent of girls having "worst spots" from 0-10 than from 30-70; and for a higher per cent of girls than boys being in the 0-10 group, and a lower per cent of girls than boys being in the 30-70 group.

These comparisons of reading attainment in relation to high-tone hearing abilities for boys and girls indicate rather conclusively that the boys account

for more of the extreme hearing loss than girls, and that the boys account for more of the below-average reading scores than girls; while the girls' hearing scores account for more of the acute *C* scores and for more of the good reading scores.

Summarizing the differences between high-tone loss and reading attainment relative to sex: in the above-average reading group the difference between the high-tone scores for boys versus girls is indicative rather than absolutely certain. In the poorest reading group there is not a real difference between *C* scores for boys and girls. Comparing the percentages of males and females in the extreme readings groups, there is a reliably greater per cent of boys than girls in the worst reading group, and a reliably greater per cent of girls than boys in the best reading group, and a reliably greater per cent of girls than boys in the best reading group. Comparing the per cents of boys and girls in the groups of most *C* loss, 70-260, and least *C* loss, 0-10, there is a reliably higher per cent of girls in the 0-10 group than in the 70-260 group; and a reliably higher per cent of boys in 70-260 than in the 0-10 groups; also there is a significantly higher per cent of girls than boys in the 0-10, and significantly higher per cent of boys than girls in the 70-260. When percentages of boys and girls are computed for the extreme *C* "worst spots," that is, 0-10 and 30-70, a reliably higher per cent of males are found in the 30-70 than in the 0-10; also a reliably greater per cent of females than males are found in the 0-10, and a reliably greater per cent of males than females in the 30-70 group.

The case for high tone association with reading attainment seems somewhat strengthened by this analysis. Girls' hearing for high tones is better than boys' hearing for high tones, and there is a relationship between high-tone loss and reading attainment; more boys are in the poorest hearing group and in the poorest reading group while more girls are in the best hearing and reading groups. In the best reading group there is not so significant a difference in the mean *C* loss for boys and girls as there is in *C* hearing for boys versus girls in the total population; and in the poorest reading group the difference in *C* scores for boys and girls is apparently due to chance. In the best reading group the boys' hearing approaches the girls' in acuity; and in the poorest reading group the girls' hearing is as bad as the boys' hearing.

The statistically significant relationship that this study has shown to exist between hearing, especially at the high frequencies, and success in reading leads to much speculation. Certainly some children with a great deal of high-tone loss achieve superior reading status; and some children with very acute hearing fail to progress in reading. Madden (65) found a correlation

of $-.123 \pm .029$ between auditory loss and intelligence, although in his study high-tone loss was disregarded. He also found the correlation between auditory loss and achievement "clustering around zero when intelligence was held constant." Definitely, intelligence must be one of the factors compensating for hearing impairment.

On the other hand, it does not seem to be taking unwarranted liberties with the findings of the present study to raise the question of a possible connection between high-tone loss and intelligence itself—as measured by tests. There is known to be a relation between intelligence quotient and reading achievement. Success on either test depends to a large extent upon language abilities and it cannot be denied that the development of various language abilities is closely associated with hearing. It is of interest to remember that Terman (96, p. 197), in his *Genetic Studies of Genius,* reports approximately 2½ times as many children in the control group with hearing impairments as in the genius group;[14] and that Pintner and others (8, p. 172) have found that the deaf as a group have lower intelligence quotients than normal hearers. Since the sense of hearing is one of the media through which one learns it is certainly conceivable that different stages of incomplete hearing contribute in varying amounts towards a lower *IQ* and that acute hearing may contribute toward a higher *IQ*.

Another speculation that might logically arise is in connection with the difference in male and female hearing for the high tones. One is led to wonder if this sex difference is in some fashion a factor contributing toward female superiority in various language abilities.

This study has in no wise attempted to designate the level at which hearing impairment is a handicap in learning to read. The chances are that it could not be done for the group as a whole. The degree to which impairment is a handicap probably depends not only upon the amount of hearing loss, but on other conditions, such as the child's age at the onset of loss, his intelligence, his constitutional make up, his eye-sight. It seems more than plausible to suggest also that many factors operating to bring about real or apparent hearing defects may likewise be operating to bring about less than average attainment in reading. Certainly the child with lowered vitality may tire before the hearing test is over just as he tires easily at his school tasks; the child who comes to school without proper or sufficient food is more easily fatigued, whatever the testing or learning situation, than the

[14]These figures were based on information obtained from school records. The author says: "The difference is probably large enough to be significant, and may be related to the fact that more of the gifted group have had adenoids and tonsils removed."

well-nourished child. There are parents who pay little attention to their child's physical or intellectual needs. A defective throat or a bad cold is allowed to run its course with the same degree of indifference that school work is allowed to progress or not progress. Other parents are constantly alert to the child's physical and intellectual needs. Some children no doubt have the same unconcern for their hearing test scores that they have for class work; while other children have an interest and a will to achieve in all situations. Close and sustained attention necessary for a successful hearing test, especially at the high frequencies, is also a necessity for most children in learning to read.

Very little is known of the causes associated with high-tone loss, and certainly we know all too little of the factors related to failure to read. When we know more of the etiology of high-tone loss it may well be that we shall also know more of the etiology of poor reading.

The reliable connection between *C* loss and reading achievement should not be interpreted to mean that the 8192 and 11,584 frequencies are necessarily the most important of the high frequencies for success in reading. The factor analysis indicated their fundamental importance only in their relation to the other tones tested. It is quite possible that some combinations of high tones other than those selected by means of the factoring would have revealed the same degree of relationship to reading achievement. Since the intercorrelations between the high tones was relatively high this supposition seems reasonable.

An attitude of conservatism should also be adopted in interpreting the fact that the study shows high-tone loss more closely connected with reading achievement than medium-tone loss. The difference is statistically real within the limits of the methods employed and within the bounds of the data, but should not be interpreted to mean that the high-tone frequencies are more important than middle-tone frequencies for learning. It should be remembered that the children in the population had reliably more *C* loss than *B* loss. *C* loss averaged approximately 12.5 decibels for each of the four scores summed, while *B* loss averaged 7.5 decibels for each of the summed scores. The 12.5 decibels at high frequcneies may represent a great deal of loss while the 7.5 at medium frequencies only a moderate amount. It is probably safe to say that a great deal of high-tone loss is more closely associated with reading than is a moderate amount of middle-tone loss. From the data it cannot be determined what differences in achievement would have appeared had the high and middle-tone losses been reversed, that is, had a great deal of middle-tone loss been accompanied by a slight or moderate amount of high-tone loss. Audiograms of this sort were not found.

On the other hand, the association found to exist between high-tone loss and achievement should not be passed over lightly because of these limitations. The relationship found between high-tone acuity and achievement is important to education. If it is true that high-tone loss is the most common type of hearing impairment found among elementary school children (22) it is definitely a very real concern of the public schools. Still further, if it is true that high-tone loss accompanied by even a slight amount of middle-tone loss has an effect on the hearing of speech (22) it follows that the distortion of speech conditioned by this type of loss can cause difficulty in learning. It may be quite true that good hearing for frequencies above the 2048 is necessary for success in only a few vocations—that loss above this range is not a handicap to the majority of adults in carrying on their ordinary daily affairs,—yet in the business of acquiring an education be quite a handicap for the child. An adult frequently gets the meaning of connected speech without hearing every sound perfectly. It is not always necessary for him even to hear every word because he is anticipating the meaning of what is being said to him. As for the child, much of his learning takes place in a room with 30 or 40 other children. If he is a "good child" the chances are that he is seated 30 or so feet from the main source of learning—the teacher—and that his limited experience cannot supply sounds or words he is not hearing completely because he cannot anticipate what is being said to the extent that the adult can. He achieves in direct proportion to his ability to form new or different concepts. His expanding concepts depend in a large measure upon his ability to deal with a rapidly expanding vocabulary. Hearing necessary for carrying on the ordinary affairs of his life—learning—may, with all logic, need to be as complete as that required for success in a few highly specialized adult professions.

It is estimated, reliably, that approximately 40 per cent of the children in an ordinary school population have some degree of high-tone impairment (22). The extent to which this loss is a handicap educationally is not known. The reports that are available indicating the tones of primary and secondary importance for speech articulation are based on their importance for adult articulation. Research should be undertaken to determine the relative importance of high and middle tones for children's interpretation of speech. A reversed order of importance might conceivably be found.

2. *Analysis of Reading Difficulty*

Durrell's *Analysis of Reading Difficulty*, a type of diagnostic test designed to identify specific areas of reading disability, was given to 98 of the chil-

dren whose reading quotient was below 100 on either reading comprehension or vocabulary as measured by the *Progressive Achievement Test.* The purpose of using an objective analysis of reading difficulty was to try to determine whether or not high-tone hearing loss might be more closely associated with certain generally recognized phases of the reading act than with others.

Very definite limitations in this approach to the problem were inherent in the data. Every child given the analytical test had some degree of reading difficulty; therefore the investigation was narrowed to an analysis of the performance of atypical readers in certain areas of reading. Further, it will be remembered that high-tone hearing loss differentiated the average and the below-average readers within the 5 per cent reliability limit only. Logically, still less differentiation in high-tone loss would be expected between the low-normal and sub-normal readers,[15] the population with which the particular problem under discussion was concerned.

Notwithstanding the obvious limitations the study was prosecuted in the hope that at least some relationships between high-tone loss and specific difficulties in reading would be indicated that might serve to suggest direction for future inquiry.

Forty-six of the children given the analytical test had reading quotients ranging from 52 to 89, and 52 had reading quotients ranging from 90 to 106. Table 23 gives certain mean comparisons for the two groups. The critical

TABLE 23

Mean Comparisons of Lowest and Highest *RQ* Groups Given the Analysis of Reading Difficulty Test as to Total *RQ*, Chronological Age, and Analytical Test Items

				Analytical test grade-placement				
				Oral reading				
N	*RQ* range	Mean *RQ*	Mean chron. age	Comp.	Recall	Silent reading	Flashed words	Pronunciation
46	52- 89	79.24	12.03	3.32	3.41	3.42	3.79	3.24
52	90-106	96.58	10.94	4.05	3.93	4.03	5.00	4.33
	CR	5.08	3.31	3.37	2.49	2.98	3.64	3.95

N	*RQ* range	Letter names missed Mean number Lower case	Letter names missed Mean number Capitals	Letter sounds missed Mean number	Blends missed Mean number
46	52- 89	1.00	1.20	10.57	7.33
52	90-106	.71	.65	9.96	6.33
	CR	1.16	1.23	.37	.88

[15]Statistical analysis was undertaken to test this supposition. The *CR* of the difference in mean *C* loss for the below-normal and the low-normal group was 1.56.

ratios indicate that there are highly reliable differences between this low-normal reading group and the sub-normal reading group in reading quotient, chronological age, Oral Reading Comprehension, Flashed Words and Word Pronunciation; a difference within the 1 per cent limit on Silent Reading; and a difference within the 5 per cent limit on Oral Reading Recall.

The poorer reading group knew fewer letter names, letter sounds, and letter blends than the low-normals but the differences were not reliable. Apparently, for the population concerned, mere knowledge of letter names and sounds, although frequently thought of as an ability connected with success in reading, is of little significance as an isolated aspect of reading.

There were 30 children in the group with high-tone loss ranging from 0-30, and 26 with high-tone loss ranging from 75-170. These ranges represented the best and poorest total *C* hearers. Table 24 shows mean grade

TABLE 24
MEAN ANALYTICAL TEST GRADE PLACEMENT FOR CHILDREN WITH LEAST AND MOST TOTAL *C* LOSS

Total *C* loss	Range 0-30 $N=30$ Mean	Range 75-170 $N=26$ Mean	Difference in achievement years
Oral reading:			
Comprehension	3.77	3.45	.32
Recall	3.67	3.49	.18
Silent reading	3.69	3.58	.11
Flashed words	4.79	4.01	.78
Word pronunciation	4.10	3.65	.45

placement attained on the analytical test for children with these extremes in high-tone hearing acuity; also the attainment differences in fractions of a year. Differences on every test item were in favor of the better high-tone hearers. The greatest difference, .78 of a year, occurred for Flashed Word scores. The critical ratio for this difference, 1.80, was also the highest critical ratio obtained.

Table 25 gives the per cents of children in both hearing groups missing each letter and blend sound. On 24 of the 26 letter sounds smaller per cents of children with the least loss missed the sounds as compared with children having the most loss. On the blend sounds the least-*C*-loss group did better than the most-*C*-loss group with 16 of the 17 blends. The average number of letter missed by the two groups was 9.8 and 13.2 respectively; the average number of blends, 6.2 and 8.3.

Test items were studied also from the standpoint of "Worst *C* Spots." There were 25 children with worst spots ranging from 0 to 10, and 27 with

TABLE 25

SHOWING PER CENTS OF CHILDREN WITH MOST AND LEAST TOTAL *C* LOSS MISSING EACH OF THE LETTER AND BLEND SOUNDS

	Range 0-30 N=26 Per cent	Range 75-170 N=30 Per cent		Range 0-30 N=26 Per cent	Range 75-170 N=30 Per cent
C	56.7	69.2	W	33.3	50.0
L	16.5	57.7	Y	53.3	73.1
A	30.0	42.3	K	40.0	50.0
S	30.0	46.2	Z	33.3	34.6
I	33.3	57.7	th	20.0	30.8
B	33.3	42.3	st	50.0	42.3
R	36.7	61.5	wh	20.0	46.2
T	36.7	34.6	sh	26.7	34.6
J	23.3	34.6	br	43.3	57.7
U	23.3	42.3	ch	36.7	38.5
M	30.0	73.1	dr	33.3	57.7
H	46.7	46.2	tr	40.0	61.5
P	26.7	34.6	cl	40.0	65.4
E	30.0	42.3	fr	36.7	50.0
F	33.3	42.3	gr	23.3	50.0
O	30.0	38.5	pl	40.0	50.0
G	43.3	73.1	sm	33.3	53.8
X	50.0	61.5	tw	43.3	46.2
N	46.7	57.7	fl	33.3	38.5
V	40.0	46.2	sk	53.3	42.3
Q	43.3	76.9	sw	50.0	65.4
D	43.3	30.8			

worst spots ranging from 30 to 55. Tables 26 and 27 show a tabulation of results. Scores on all test items including letter and blend sounds favor the 0-10 group. The only difference approaching reliability, however, is on Flashed Word scores. The difference of .94 of a year has a critical ratio of 2.3 (within the 5 per cent limit). The 0-10 group missed an average of 8.8 letter and 5.1 blend sounds; while the 30-55 group missed an average of 12.4 and 8.2 on letter and blend sounds respectively.

Since the better high-tone hearers knew more of the letter and blend sounds

TABLE 26

SHOWING MEAN ANALYTICAL TEST GRADE PLACEMENT FOR CHILDREN WITH "WORST *C* SPOT" FROM 0-10 AND THOSE WITH "WORST *C* SPOT" FROM 30-55

Worst *C* spot	Range 0-10 N=25 Mean	Range 30-55 N=27 Mean	Difference in achievement years
Oral reading:			
Comprehension	3.76	3.41	.35
Recall	3.71	3.39	.32
Silent reading	3.71	3.50	.27
Flashed words	4.84	3.90	.94
Word pronunciation	4.00	3.63	.37

TABLE 27

SHOWING PER CENTS OF CHILDREN WITH "WORST *C* SPOT" FROM 0-10 AND THOSE WITH "WORST *C* SPOT" FROM 30-55 MISSING EACH OF THE LETTER AND BLEND SOUNDS

	Range 0-10 $N=24$ Per cent	Range 30-55 $N=26$ Per cent		Range 0-10 $N=24$ Per cent	Range 30-55 $N=26$ Per cent
C	50.0	65.4	W	29.2	42.3
L	45.8	61.5	Y	41.7	65.4
A	25.0	34.6	K	33.3	50.0
S	20.8	42.3	Z	33.3	38.5
I	25.0	53.8	th	8.3	38.5
B	33.3	34.6	st	41.7	38.5
R	29.2	53.8	wh	12.5	50.0
T	33.3	34.6	sh	16.7	34.6
J	29.2	34.6	br	33.3	53.8
U	16.7	38.5	ch	20.8	46.2
M	25.0	46.2	dr	20.8	53.8
H	45.8	46.2	tr	33.3	50.0
P	20.8	34.6	cl	41.7	50.0
E	33.3	46.2	fr	29.2	50.0
F	41.7	46.2	gr	16.7	42.3
O	25.0	42.3	pl	33.3	53.8
G	37.5	57.7	sm	29.2	53.8
X	50.0	61.5	tw	45.8	50.0
N	37.5	57.7	fl	25.0	46.2
V	37.5	50.0	sk	54.2	42.3
Q	41.7	73.1	sw	45.8	65.4
D	37.5	30.8			

than the poorer hearers, the letters missed by both groups were tabulated according to Steinberg's classification of speech sounds (89). By means of articulation tests Steinberg was able to designate the frequency regions of greatest importance for hearing the vowels, nasal consonants, stop consonants, and fricative consonants.[16] It will be noted that the recognition of speech sounds in each of these divisions necessitates hearing at increasingly higher frequencies. Although the letters in this classification involve a wide range of frequencies it was thought possible that grouping the letters by such a scheme might serve to establish some relationship between the type of speech sounds missed and hearing acuity. This was not the case, however. The poorer hearers missed more of the sounds in each of the divisions than the better hearers, but the sounds they missed fell uniformly throughout the vowel and consonant range as was also true for those missed by the better hearers.

Further study of the analysis test data was not undertaken since the study

[16]

Vowels, short and long (*a e i o u w v*)	Frequencies	200-3000
Nasal consonants (*l m n ng r*)	"	500-4000
Stop consonants (*b ch d g h j k p t*)	"	750-5000
Fricative consonants (*f s sh st th' th v z zh*)	"	1000-8000

that was made seemed unproductive of discovering areas of reading that were unquestionably associated with high-tone loss. Because of the narrow extent of the study, and the serious limitations of the data as pointed out earlier, this section of the report should be considered suggestive only.

Summarizing analysis of reading difficulty: scores on the separate test items reliably differentiated the low-normal readers and sub-normal readers except for items testing knowledge of letters and blends. Apparently the ability to call the letter names or to produce the sounds of isolated letters and blends is no more reliably associated with a low-normal reading score than it is with a sub-normal reading score insofar as the immediate study is concerned.

When scores for letter and blend sounds are compared for the children with the most *C* loss and the least *C* loss, and again for children with good "worst spots" and bad "worst spots" it is found that the better high-tone hearers in both of the categories miss fewer sounds than the poorer hearers. Even though poorer high-tone hearers miss more of the speech sounds than do the better hearers, they miss no more of the sounds that involve high-tone frequencies than of the ones that involve lower frequencies. Seemingly, the ability to deal with isolated speech sounds is an "over all" ability. This may be due to the fact that all speech sounds are highly complicated in both frequency and pressure patterns. Thus, loss for high-frequency hearing *may* render the learning of all speech sounds difficult.

Flashed Word scores differentiated the better and poorer *C* hearers more reliably than did other test item scores. Why this should be true is, to say the least, obscure. A study of the Flashed Word test of the child with the greatest high-tone loss reveals an interesting phenomenon. The case is a 12-year-old girl with a reading quotient of .87. She knew all of the letter names but one; knew 14 of the 26 letter sounds and 7 of the 17 blend sounds. When the word *polish* was flashed she said "police." She was asked what letters she remembered seeing and replied "p-o-l-i-s-h." The word was then re-exposed—as provided by the test directions—and time allowed for study. The child continued to call it "police." She called *Blunt*, "blank," remembered the letters in correct order but upon re-exposure and study still called the word "blank." She called *ceiling*, "calling," again remembered the letters and continued to say "calling," even with the word before her. This happened repeatedly. The visual memory for letters exhibited by the child was remarkable, but she possessed no ability to arrive at the correct pronunciation of the words that she did not know at a glance. This child's reaction to *words* was duplicated by other children, and leads one to wonder

whether or not an ability to analyze and synthesize word parts may be related to the knowledge of speech sounds as they are combined into words. What part the loss for high frequencies could play in such an ability is mere conjecture of course. The fact that this study found a high degree of reliability between reading attainment and high-tone acuity and some degree of reliability between Flashed Word scores and high-tone acuity suggests that the ability to deal successfully with words *may* bear a relationship to the ability to hear word parts accurately.[17] Further study in this direction might be worth while.

C. External Otological Data

The results of the external otological examinations will be presented in relation to hearing loss at low, medium, and high frequencies (*A, B,* and *C* loss). Little effort will be made to interpret the relationships that are found to exist since interpretation involves the field of otology.

The otological examination took place within a few weeks of the hearing test. Certainly any lapse of time between the test and examination might tend toward creating spurious relationships; however, a few of the associations between certain types of loss and otological defects seem consistent enough to suggest that factors unrelated to the lapse of time may be accountable in some measure.

Table 28 shows the mean *A, B,* and *C* loss for the total population, for those free of the defects revealed by the external otological examination, and for those having various subdivision defects.

Table 29 gives the same information, mean *A, B,* and *C* loss, except for *defective* or *not defective,* with the critical ratios of the differences. It is noted that for six of the seven categories of defects the mean *A, B,* and *C* loss is greater for children having the defects than for those not having the defects. The one exception is mean high-tone loss for children with nasal obstructions and infections. Their mean high-tone loss is 0.9 decibels better than children having no nasal defects.

Children with normal throats hear *A, B,* and *C* tones better than children with defective throats. The greatest mean difference is at the low tones. Those with normal throats, tonsils in and no defects, hear low tones, *A,* better by 5.70 decibels than children with defective throats. The critical ratio of the difference is 2.68, indicating that the difference could have happened by chance less than 1 per cent of the times. Those with normal throats

[17]The correlation between reading quotient and Flashed Word score for the total diagnostic test group was .26±.06—a slight but real association.

TABLE 28

MEAN *A*, *B*, AND *C* LOSS FOR CHILDREN WITH VARIOUS OTOLOGICAL DEFECTS

	N	*A*	*B*	*C*
Throat				
Normal and tonsils in	94	20.00	26.10	47.15
Normal and tonsils out	77	21.50	29.00	37.55
Regrowth	6	21.20	22.50	52.55
Imbedded	6	17.50	22.50	47.45
Chronic infection or congestion	48	31.90	34.40	59.00
3+ (enlarged)	54	27.30	32.10	58.85
No record	2			
Left Ear Canal				
Normal	270	22.90	28.50	47.75
Acute infection	1	92.50	72.50	65.00
Congestion	1	22.50	12.50	2.50
Subsiding or recent infection	1	32.50	42.50	95.00
Cerumen	9	33.60	39.20	75.00
No record	5			
Right Ear Canal				
Normal	273	23.50	28.80	48.35
Acute infection	0			
Congestion	0			
Subsiding or recent infection	0			
Cerumen	9	25.80	35.80	58.40
No record	5			
Left Eardrum				
Normal	254	22.60	27.70	46.55
Questionable old infection	15	29.90	39.20	56.00
Definite old infection	1	12.50	12.50	35.00
Recent infection	2	47.50	77.50	117.00
Combination of old and new	3	52.50	45.80	95.00
Not seen for wax	7	26.80	36.70	73.55
No record	5			
Right Eardrum				
Normal	256	22.40	27.50	46.85
Questionable old infection	13	37.90	47.10	59.30
Definite old infection	2	22.50	17.50	35.00
Recent infection	3	39.20	75.70	114.95
Combination old and new	1	32.50	2.50	65.00
Not seen for wax	7	31.10	36.70	69.35
No record	5			
Nasal Passages				
Normal	240	22.50	27.60	48.80
Acute infection	16	28.10	28.70	51.80
Chronic or subsiding infection	7	31.10	43.90	41.45
Obstructions	16	28.10	40.00	46.25
Combination of chronic infection and obstruction	3	39.20	52.50	50.00
No record	5			

TABLE 29
MEAN A, B, AND C LOSS FOR DEFECTIVES AND NON-DEFECTIVES

	N	A	B	C	Total A, B, C
Throat					
Normal	94	20.00	26.10	47.15	
Defective	191	25.70	30.80	49.70	
Critical Ratio		2.68	1.83	0.57	2.69
Left Ear Canal					
Normal	270	22.90	28.50	47.75	
Defective	12	37.50	40.00	69.95	
Critical Ratio		1.80	1.50	1.68	2.88
Right Ear Canal					
Normal	273	23.50	28.80	48.35	
Defective	9	25.80	35.80	58.40	
Critical Ratio		0.43	1.16	0.81	1.38
Left Eardrum					
Normal	254	22.60	27.70	46.55	
Defective	28	32.10	41.10	68.15	
Critical Ratio		2.12	2.98	2.67	4.47
Right Eardrum					
Normal	256	22.40	27.50	46.85	
Defective	26	34.80	43.70	66.80	
Critical Ratio		2.70	3.38	2.61	5.01
Nasal Passages					
Normal	240	22.50	27.60	48.80	
Defective	42	29.40	37.30	47.90	
Critical Ratio		1.66	2.40	0.16	2.33
Teeth					
No Caries	194	22.70	28.90	46.25	
Caries	90	26.00	30.10	54.65	
Critical Ratio		1.18	0.42	1.81	2.00

hear medium tones, B, 4.70 decibels better than the defectives, and high tones, C, better by 2.55 decibels, but the B and C differences for the defectives and non-defectives are not statistically reliable with critical ratios of 1.83 and 0.57. When A, B, and C losses are combined the critical ratio of the mean difference is 2.69, within the 1 per cent limit, and therefore indicative of a relationship between total low, middle, and high-tone loss and condition of the throat.

Children with normal ear canals have better A, B, and C hearing than children with canal infections, congestion or cerumen, but the differences are not reliable for A, B, and C tones separately. When low, middle, and high-tone loss is totaled, however, the mean difference in loss for defectives and non-defectives has a critical ratio of 2.88 for the left ear, indicating a relationship within the 1 per cent reliability limit. This degree of reliability does not hold for the right ear canal differences, however.

The condition of the tympanic membrane bears a relationship to loss at low, middle, and high-tones for both ears. The mean difference in acuity at the low tones in favor of children with normal membranes is 9.50 decibels, left ear; and 12.40 decibels, right ear. The critical ratios for left and right ear differences, low tones, are 2.12 (within the 5 per cent limit) and 2.70 (within the 1 per cent limit) respectively. For the *B* tones the mean difference in loss for those with defective eardrums and those with normal eardrums is 16.20 decibels, left ear, and 9.70 decibels, right ear, with critical ratios of 2.98 (within the 1 per cent limit of reliability), and 3.38 (virtual certainty). High-tone loss is 21.60 decibels greater, left ear, and 19.16 greater, right ear, for children with eardrum defects than for children without such defects. The critical ratios are 2.67 and 2.61, both within the 1 per cent limit. When the loss for low, middle, and high tones is combined, the critical ratios of the mean differences between the defectives and non-defectives are 4.47 left ear, and 5.01 right ear. Critical ratios of such magnitude preclude any chance association.

Children without nasal infections or obstructions hear the low tones, *A*, 6.90 decibels more keenly than children with nasal defects, but the difference is not reliable (*CR* 1.66). The non-defectives hear middle tones, *B*, better than the defectives by 9.70 decibels, with a critical ratio of 2.40, which is within the 5 per cent limit. The defectives hear the high tones, *C*, 0.9 decibels better than the non-defectives, *CR* 0.16, indicating that the difference is due to chance. When the *A*, *B*, and *C* loss is totaled for the defectives and non-defectives the critical ratio of the mean difference is 2.33, within the 5 per cent reliability limit.

Children with no unfilled dental cavities hear the low tones slightly better, 3.30 decibels (*CR* 1.18), than children with unfilled cavities; they hear the middle tones very little better, 1.20 decibels (*CR* 0.42); and they hear the high tones 8.40 decibels better (*CR* 1.81). These critical ratios are not statistically reliable. When the total *A*, *B*, and *C* mean loss for children with dental cavities is compared with the total *A*, *B*, and *C* mean loss for children without cavities, the critical ratio of the difference is 2.00—within the 5 per cent limit of reliability.

These comparisons of mean differences in hearing acuity for children with and without certain external otological defects show the existence of certain relationships that are indicative of significance: Low-tone loss seems to accompany defective throats and defective tympanic membranes, including evidences of past membrane infections, to an extent that is suggestive of a significant relationship; the incidence of a middle-tone loss that accompanies

defective tympanic membranes and defective nasal passages is high enough statistically to be viewed as a significant association; high-tone loss is reliably associated with only one type of external otological defect—tympanic membrane. When low, middle, and high-tone losses are combined the total loss accompanies defects within varying degrees of reliability. Relationship of total loss to the condition of the eardrum is unquestionably reliable; relationship to left ear canal is significant within the 1 per cent limit; relationships between conditions of the throat, of the nasal passages and of the teeth, are reliable within the 5 per cent limit.

Defects accompanying keen hearing as opposed to those accompanying very poor hearing were tabulated. There were 94 children whose *A* scores ranged from 0-10 and 80 whose *A* scores ranged from 35-260. These two groups represent the two extremes in low-tone loss. The numbers and per cents of children in the two hearing groups having the various defects are shown in Table 30. The greatest differences in per cents occur in connection with

TABLE 30
NUMBERS AND PER CENTS WITH VARIOUS OTOLOGICAL DEFECTS IN THE BEST AND POOREST *A* HEARING GROUPS

	0-10 Loss		35-260 Loss	
	N	Per cent	*N*	Per cent
Throat				
Tonsils in and throat normal	28	29.79	20	25.64
Tonsils out and throat normal	34	36.17	20	25.64
Tonsils out, but regrowth	2	2.13	—	—
Tonsils imbedded	1	1.06	—	—
Tonsils chronically infected or congested	14	14.89	18	23.08
3+ (enlarged)	15	15.96	20	25.64
Left Ear Canal				
Normal	93	98.94	70	92.11
Defective	1	1.06	6	7.89
Right Ear Canal				
Normal	93	98.94	73	96.05
Defective	1	1.06	3	3.95
Left Eardrum				
Normal	89	94.68	63	82.89
Defective	5	5.32	13	17.11
Right Eardrum				
Normal	91	96.81	64	84.21
Defective	3	3.19	12	15.79
Nasal Passages				
Normal	83	88.30	62	81.58
Defective	11	11.70	14	18.42
Dental				
No caries	64	68.09	50	64.10
Caries	30	31.91	28	35.90

the throat. There are 36.17 per cent in the 0-10 group with tonsils out and throat normal against 25.64 per cent in the 35-260 group. In the 0-10 group 14.89 per cent have chronic throat infection or congestion, while 23.08 per cent in the 35-260 group have the same defect. Ten per cent fewer children in the 0-10 group have 3+ tonsils than in the 35-260 group. However, in the 0-10 group there are only 4.15 per cent more children with tonsils in and throat normal than in the 35-260 group.

The per cents of children in the 0-10 and the 35-260 groups having nasal defects, ear canal defects, and unfilled dental cavities are approximately the same. In the 0-10 group 11.79 per cent fewer children have left ear tympanic membrane defects than in the 35-260 group, and 12.60 per cent fewer, right ear.

For each otological division higher per cents of children in the 35-260 *A* hearing group have defects than in the 0-10 group, but in no case is the per cent difference statistically reliable. If a child has keen *A* hearing his chance of having an otological defect is approximately equal to that of the child with very poor *A* hearing. Keen *A* hearing does not portend *no defect* as poor *A* hearing does not portend *a defect*. This certainly suggests that factors other than, or in addition to, observable otological defects must be sought for the causes responsible for low-tone loss.

There are 74 children in the 0-10 *B* hearing group and 71 children in the 45-115 *B* hearing group—Table 31. These amounts of *B* loss represent the least and the most middle-tone loss. As with the extreme *A* groups the greatest difference in percentages occurs in the matter of throat defects. There are 41.19 per cent in the 0-10 group and 24.29 per cent in the 45-115 group with normal throats—tonsils in and throat normal. Normal ear-drums occur in the 0-10 group in 95.95 per cent of the cases, left ear; and 97.30 per cent, right ear, against 80.88 per cent and 75.00 per cent in the 45-115 group. There are only 75 per cent of the children in the 45-115 group against 89.19 per cent in the 0-10 group with nasal defects. Per cents of defects in the other categories differ practically none in the 0-10 and 45-115 groups; however, in all excepting dental, the 0-10 group have a higher per cent of normal conditions than have the 45-115 group. Again, as with *A* loss, in no instance is the difference in percentage statistically significant. The child with keen *B* hearing is just as likely, statistically, to have an otological defect as is the child with a great deal of *B* loss; and the child with a great deal of *B* loss is no more likely to have a defect than is the child with little loss. The children having certain defects as a group—Table 29—have reliably more *B* loss than children as a group not having

TABLE 31
NUMBERS AND PER CENTS WITH VARIOUS OTOLOGICAL DEFECTS IN THE BEST AND POOREST *B* HEARING GROUPS

	0-10 Loss		45-115 Loss	
	N	Per cent	*N*	Per cent
Throat				
Tonsils in and throat normal	31	41.89	17	24.29
Tonsils out and throat normal	22	29.72	21	30.00
Tonsils out but regrowth	—	—	—	—
Tonsils embedded	1	1.35	—	—
Tonsils chronically infected or congested	8	10.81	16	22.86
3+ (enlarged)	12	16.22	16	22.86
Left Ear Canal				
Normal	72	97.31	64	94.12
Defective	2	2.69	4	5.88
Right Ear Canal				
Normal	73	98.65	65	95.59
Defective	1	1.35	3	4.41
Left Eardrum				
Normal	71	95.95	55	80.88
Defective	3	4.05	13	19.12
Right Eardrum				
Normal	72	97.30	55	80.88
Defective	2	2.70	13	19.12
Nasal Passages				
Normal	66	89.19	51	75.00
Defective	8	10.81	17	25.00
Dental				
No caries	51	68.92	49	70.00
Caries	23	31.08	21	30.00

those defects, but the relationship breaks down when the groups studied are composed of those with little *B* loss and those with a great deal of *B* loss. Consequently, it will have to be concluded that as far as this investigation is concerned external otological defects *may* operate as one factor associated with middle-tone loss. As with low-tone loss, however, no causal relationship is established.

There are 73 children with high-tone scores ranging from 0-20 and 73 with scores ranging from 70-260, representing the worst and the best *C* scores—Table 32. In the 0-20 group there is a larger percentage of children with no defects in each of the otological categories than in the 70-260 group. As with *A* and *B* percentages, throat conditions account for the largest differences between the extreme *C* hearing groups. In the 0-20 group 36.99 per cent have tonsils in and throat normal against 31.51 per cent in the

TABLE 32

NUMBERS AND PER CENTS WITH VARIOUS OTOLOGICAL DEFECTS IN THE BEST AND POOREST *C* HEARING GROUPS

	0-20 Loss		70-260 Loss	
	N	Per cent	N	Per cent
Throat				
Tonsils in and throat normal	27	36.99	23	31.51
Tonsils out and throat normal	30	41.10	15	20.55
Tonsils out but regrowth	2	2.74	2	2.74
Tonsils embedded	—	—	1	1.37
Chronic infection or congestion	7	9.59	16	21.92
3+ (enlarged)	7	9.59	16	21.92
Left Ear Canal				
Normal	70	95.89	65	91.55
Defective	3	4.11	6	8.45
Right Ear Canal				
Normal	70	95.89	68	95.77
Defective	3	4.11	3	4.23
Left Eardrum				
Normal	70	95.89	57	80.28
Defective	3	4.11	14	19.72
Right Eardrum				
Normal	71	97.26	59	83.10
Defective	2	2.74	12	16.90
Nasal Passages				
Normal	65	89.04	61	85.92
Defective	8	10.96	10	14.08
Dental				
No caries	57	78.08	44	60.27
Caries	16	21.92	29	39.73

70-260 group. For the keenest hearers 41.10 per cent have tonsils out and throat normal compared with 20.55 per cent for the 70-260 group. In the 0-20 group 9.59 per cent have chronic throat infections and 9.59 per cent have 3+ tonsils, while in the 70-260 group 21.92 per cent have chronic throat infections and 21.92 have 3+ tonsils. In the least-*C*-loss group 4.35 per cent fewer have left ear canal defects, and 0.12 per cent fewer have right ear canal defects than in the most *C* loss group. Percentage differences in tympanic membrane defects are 15.61 per cent left ear, and 14.16 per cent right ear in favor of the best *C* hearers. The difference in nasal passage defects is 3.16 per cent in favor of the best *C* hearers. There are 17.81 per cent fewer in the 0-20 group with caries than in the 70-260 group. While these differences are all in favor of the 0-20 groups having a larger per cent of non-defectives than the 70-260 group, in one instance only is there a reliable difference in the percentages: when the per cents of children with

normal throats, tonsils in or out, are compared for the best and poorest C hearers 78.09 per cent in the best group and 52.06 per cent in the worst group have normal throats. The CR of the difference is 2.07, which is within the 5 per cent limit. However, when mean C loss, Table 29, was compared for the throat defectives, and non-defectives, the CR of the mean differences was indicative of no more than a chance relationship. So, as with low and middle-tone loss this study has failed to find a causal relationship between loss at the high tones and external otological defects.

When low, middle, and high-tone loss is totaled and the poorest and best hearers compared from the standpoint of defects the results are practically the same as those obtained when A, B, and C loss are studied separately. Tabulations for total loss are shown in Table 33. There are 70 children whose total A, B, and C loss ranges from 145 to 730 decibels, and 67 whose loss ranges from 10-50 decibels. There are 29.64 per cent more children with normal throats, tonsils in or out, in the keenest hearing group than there are in the poorest hearing group. The critical ratio of the per cent

TABLE 33
NUMBERS AND PER CENTS WITH THE POOREST AND BEST (COMBINED A, B, AND C LOSS) HEARING HAVING VARIOUS OTOLOGICAL DEFECTS

	10-50 Loss		145-730 Loss	
	N	Per cent	N	Per cent
Throat				
Throat normal—tonsils in	24	35.82	17	24.64
Throat normal—tonsils out	27	40.30	15	21.74
Throat defective	16	23.88	36	53.62
Left Ear Canal				
Normal	65	97.01	61	91.04
Defective	2	2.99	6	8.96
Right Ear Canal				
Normal	67	100.00	64	95.52
Defective	—	—	3	4.48
Left Eardrum				
Normal	65	97.01	55	82.09
Defective	2	2.99	12	17.91
Right Eardrum				
Normal	67	100.00	56	83.58
Defective	—	—	11	16.42
Nasal Passages				
Normal	60	89.55	55	82.09
Defective	7	10.45	12	17.91
Dental				
No caries	48	71.64	45	65.22
Caries	19	28.36	24	24.78

difference is 2.29 (within the 5 per cent limit). The differences in per cents of defectives and non-defectives in the best and poorest hearing groups in all other categories are statistically unreliable.

Apparently there is a relationship between hearing loss in general and the condition of the throat. Table 29 showed the mean loss for defectives and non-defectives. The mean difference in total low, middle, and high-tone loss for the defectives and non-defectives had a critical ratio of 2.69 (within the 1 per cent limit); and since the percentage differences for best and poorest hearers—total *A*, *B*, and *C* loss—with normal throats has a critical ratio of 2.29, it would seem that defective throats *may* be operative in bringing about hearing loss of a general nature.

There is an opinion (72) that boys have more otological defects than girls. For this reason a tabulation was made of defects for the total number of children in the study, 143 males and 144 females—Table 34. Standard

TABLE 34
OTOLOGICAL DEFECTS FOR MALES, FEMALES AND TOTAL POPULATION

	Male		Female		Total	
	N	Per cent	*N*	Per cent	*N*	Per cent
Throat						
Tonsils in and throat normal	49	34.26	45	31.69	94	32.98
Tonsils out and throat normal	29	20.28	48	33.80	77	27.02
Tonsils out but regrowth	3	2.10	3	2.11	6	2.11
Tonsils imbedded	2	1.40	4	2.88	6	2.11
Chronically infected or congested	29	20.28	19	13.38	48	16.84
3+ (enlarged)	31	21.68	23	16.20	54	18.95
Left Ear Canal						
Normal	140	97.90	130	93.53	270	95.74
Defective	3	2.10	9	6.47	12	4.26
Right Ear Canal						
Normal	140	97.90	133	95.68	273	96.81
Defective	3	2.10	6	4.32	9	3.19
Left Eardrum						
Normal	126	88.11	128	92.09	254	90.07
Defective	17	11.89	11	7.91	28	9.93
Right Eardrum						
Normal	128	89.51	128	92.09	256	90.76
Defective	15	10.49	11	7.91	16	9.24
Nasal Passages						
Normal	116	81.12	124	89.21	240	85.11
Defective	27	18.88	15	11.79	42	14.89
Dental						
No Caries	89	62.68	105	73.94	194	68.31
Caries	53	37.22	37	26.06	90	31.69

errors of the per cents of males and females and critical ratios of the differences were computed for all of the categories of defects except ear canals. The difference of the per cents with ear canal defects was obviously too slight to be reliable. A slightly higher per cent of boys, 2.57, than girls have tonsils in and throat normal; also the per cent of boys without ear canal defects, left ear, is 4.37 higher than per cent of girls; right ear 2.22 per cent higher than girls. There are 13.52 per cent more girls than boys with tonsils out and throats normal; 3.98 per cent more girls than boys with normal left ear tympanic membranes, and 2.58 per cent, right ear; 8.09 per cent more girls without nasal passage defects; and 11.26 per cent more girls without caries. The critical ratios of the per cent differences, male and female are: throat 1.27; tympanic membrane, left ear, 0.37, right ear 0.24; nasal passages, 0.82; dental, 1.26. As far as this study is concerned there is certainly not a reliable difference between the sexes regarding any of the external otological defects noted.

Average number of defects for the poorest and best hearers, *A*, *B*, and *C*, male and female, are shown in Table 35. In every case children with the

TABLE 35
AVERAGE NUMBER OF OTOLOGICAL DEFECTS FOR POOREST AND BEST HEARERS, MALE AND FEMALE AND TOTAL POPULATION

	N	Male	*N*	Female	*N*	Total
A Loss						
0-10	49	1.14	45	0.60	94	0.88
35-260	36	1.64	44	1.31	80	1.46
B Loss						
0-10	35	0.89	39	0.64	74	0.76
45-115	39	1.69	32	1.19	71	1.49
C Loss						
0-20	26	0.81	47	0.64	73	0.70
70-260	47	1.38	26	2.25	73	1.63
Total A, B, C						
10-50	27	0.82	40	0.60	67	0.69
145-730	38	1.50	32	1.72	70	1.60
Total Population	143	1.28	144	0.99	287	1.14

least loss average fewer defects than children with most loss and fewer than children of the total population. Children with the most loss in every case have an average of more defects than children of the total population. Girls average fewer defects than boys except in the poorest *C* hearing group. Here the average number of defects for males is 1.38 and for females is 2.25.

The statistical treatment used to try to determine the relationship between

hearing loss and otological defects has showed that an association exists, but in one instance only are the facts suggestive of a causal relationship: the difference in the total *A*, *B*, and *C* mean losses for children with and for those without throat defects (Table 29), has a critical ratio of 2.69 (within 1 per cent reliability), and the critical ratio of the differences in per cents of throat defectives in the poorest and best total *A*, *B* and *C* group (Table 33) is 2.07 (within the 5 per cent limit). These critical ratios are high enough for the conclusion that total low, middle, and high-tone loss is related in some fashion to throat defects. A close relationship is not indicated, however, when low, middle or high-tone losses are considered separately.

While there is no evidence within the limits of the data and their treatment that otological defects cause hearing loss, with the possible exceptions mentioned in the foregoing paragraph, hearing loss and defects coexist; so, quite plausibly, some of the factors that are tending to bring about hearing loss are also operating to bring about otological defects. Some parents may be forced by circumstances to pay little attention to a discharging ear or to a chronically infected throat, while others treat even a minor earache or an unfilled cavity with immediate concern. A comparison of the hearing loss of children whose families were on government relief[18] with loss of those whose families were not seems to give some support to this hypothesis.

Table 36 shows *A*, *B*, and *C* loss for the 30 children of relief families and the 252 children of families ostensibly in better economic circumstances.

TABLE 36
A, *B*, AND *C* MEAN LOSS FOR RELIEF AND NON-RELIEF GROUPS

	N	*A* loss	*B* loss	*C* loss
Relief	30	27.20	36.70	53.75
Non-relief	257	23.30	28.30	48.35
CR		1.02	2.04	0.82

The children of relief families have more low, middle, and high-tone loss than children of better financial status, but only for *B*, the middle tones, does the mean differences approach reliability. The critical ratio of 2.04 is within the 5 per cent limit and indicative of differentiation. When *A*, *B*, and *C* losses are combined the mean difference between relief and non-relief has a critical ratio of 2.23, also within the five per cent limit and a slightly higher reliability than *B* loss alone. Extent to which such matters as nutrition are involved are problematic, of course.

[18]Families on relief at the time of the test or during the two-year period prior.

Other investigations have reported a relationship between hearing loss and economic level. Berry (7) maintains that there is a consistently higher prevalence of defective hearing in the lower income groups; Macnutt (64) says that the numbers of children in crowded tenement districts with hearing impairment is often ten times as great as in better sections; Waters (102) reports the children with hearing defects range from 4 per cent where economic conditions are adequate to 15 per cent where economic conditions are inadequate.

Studies are not, however, conclusive in their reports as to the etiology of hearing impairment. Hunt (54), basing his conclusions on the audiometric and otological examinations that have been in progress for several years among public school children of New York, says that apparently diseased tonsils, sinus infection, and turbinate pathology are among the factors effective in producing hearing impairment. Neuschutz (81) says that diseased tonsils are one earmark of defective hearing. Gardner (41) reports a close relationship between infections of the nose and throat and hearing difficulties. He has found that among children with hearing difficulties 35 to 40 per cent have chronic colds, from 30 to 40 per cent have suspicious tonsils, from 20 to 25 per cent are mouth breathers, and from 60 to 80 per cent have scars on the drum membranes. Fishbein (27) believes that most deafness is preventable, "that it involves the prevention of contagious diseases and colds, and the treatment of infected tonsils and adenoids and the proper care of the ears." Ciocco (15) reported the results of hearing tests and otological examinations given to approximately 1400 Washington, D. C., school children. Half the number had a hearing loss of 9 or more sensation units, and half showed a hearing loss not greater than six sensation units when tested by means of a group audiometer. He says that, owing to the lack of precision of group testing instruments, the hearing of these children cannot be considered completely representative of the hearing of children in the general population. All of the children were, however, retested with an individual audiometer. The otoscopic examination revealed a relationship between hearing loss throughout the audiometric range and conditions of the tympanic membrane, to the extent that Ciocco concluded "changes in the tympanic membrane . . . do affect the hearing acuity sufficiently to be detected." On the other hand he found no relationship between the type or degree of hearing loss and nasal or throat conditions.

Conclusions that may be drawn from the present investigations, within the limits of the data and their treatment are: (*a*) low-tone loss accompanies defective throats and defective eardrums; (*b*) middle-tone loss accompanies

defective eardrums and nasal passages; (*c*) high-tone loss accompanies defective eardrums; general loss accompanies eardrum, throat, nasal passage, and dental defects.

Larger per cents of children in the worst hearing groups, *A*, *B*, and *C*, have otological defects than of those in the best *A*, *B*, and *C* hearing groups. This holds for every otological category; but only in the case of throat defects for the best and poorest *C* hearers does the difference in per cent approach a reliable difference. Smaller per cent of children with the least total *A*, *B*, and *C* loss have otological defects than of children with the greatest amount of total loss; the differences in per cents with throat defects is indicative.

Children with poor hearing at *A*, *B*, and *C* tones average a greater number of defects than children with good *A*, *B*, and *C* hearing; children with poor combined *A*, *B*, and *C* hearing average a greater number of defects than children with good combined *A*, *B*, and *C* hearing. Girls have fewer otological defects than boys, but the differences are statistically unreliable. Children of poorest economic status have more *B* loss and more general loss than children from better homes; but the relationship is suggestive rather than positive.

State Teachers College
Farmville, Virginia

The Journal of Genetic Psychology, 1947, **71**, 49-63.

CHILDREN'S AUDIOGRAMS IN RELATION TO READING ATTAINMENTS: III. DISCUSSION, SUMMARY, AND CONCLUSIONS*

Department of Psychology, University of North Carolina

SIBYL HENRY

Investigators have employed a multiplicity of attacks in attempting to analyze the complex processes involved in the reading act. Consequently a great deal of scientific information is available. Research has failed, however, to isolate the factors conditioning reading development to the extent that it can be said with certainty why some children learn to read with no apparent difficulty, why others learn eventually but with painfully slow progress, and why others never learn "up to standard." Inadequacy of the implements of research for identifying, measuring, and evaluating phenomena involved in the process of reading has occasioned conflicting research findings and differences of opinion among reading specialists. Lack of agreement serves to call attention to many unsolved problems with which learning to read are concerned.

The intelligence quotient which is relied upon consistently in predicting success in reading is usually found to have a correlation of .50 or .60 with reading progress, yet many children read with less success than prognosis based on their intelligence quotients would indicate while others achieve beyond expectations. Reading-defect cases are found to have all degrees of intelligence from very low to very superior—with a normal distribution of intelligence quotients (69). In considering the relations of intelligence to reading achievement it should be remembered also, that while low intelligence tends to cause low reading scores, poor reading ability can be one cause of a low intelligence quotient.

Neither do reading-readiness tests have the high prognostic value once hoped for. Factors other than those measured by such tests are apparently important in the determination of successful reading development. Even the mental age necessary for learning to read seems to be dependent upon so many factors that Gates (98, p. 9) is led to say that statements specifying such mental age requirements are essentially meaningless.

Studies of reversal tendencies, handedness, and eyedness as indicative of

*Received in the Editorial Office on June 1, 1946.

possible factors associated with reading development are numerous. Followers of Orton (83) believe that some reading difficulties are due to the individual's failure to establish unilateral cortical dominance, and that reversals and mixed handedness and eyedness are manifestations of this failure. However, other investigators present conflicting evidence as to plausibility of the dominance theory as related to reading difficulties as well as to the relationship of reversals, handedness, and eyedness to reading difficulties.

Numerous studies have investigated the relation of reading development to visual defects, especially such defects as eye muscle imbalance and inability to fuse. The lack of agreement in the findings leads to uncertainty as to the relationship.

Research that has been done to establish the importance of eye-movements—fixations, span, and regression—to reading does not warrant assurance in assigning faulty eye-movements as a cause for poor reading.

Investigations of intensive versus extensive reading methods lead to these conclusions: some children profit more by one method while others profit more by another method; or, one method may be more beneficial for developing certain reading skills while another may be more beneficial for developing other reading skills.

Studies of personality maladjustments have not clearly established a causal relationship with reading problems, although some studies tend to show that emotional strain may be alleviated to an extent by improvement in reading.

Auditory abilities as related to reading attainment have not received their share of concern through scientific investigation. Several reading specialists, however, admit a possible relationship, and suggest tests for indicating ability to distinguish likenesses and differences in spoken words and sounds, ability to fuse sounds into words, and memory span for sounds (69, 45, and 9).

Gates (44, p. 400) states that "there is some evidence that some children have deficiencies for tones within a certain range only, which may make phonetic exercises difficult." Monroe's studies (69, p. 107) of remedial cases lead her to suspect that some children not noticeably hard of hearing may have difficulty with certain pitches. Betts (9, ch. X) devotes several pages to a discussion of the auditory factors that may be related to reading. Wright (111, p. 249) calls attention to the fact that factors such as auditory span, perception and range, and ability to fuse sounds, as well as hearing acuity, may be significantly related to the determination of reading-readiness.

Traxler (98, p. 34) considers Bond's study of the auditory and speech characteristics of poor readers to be the principal contribution directly perti-

nent to the relationship between auditory factors and reading achievement. Bond (10), by averaging the hearing loss in the better ear throughout the audiometric range to determine hearing acuity, and by using a battery of self-devised tests for scoring auditory discrimination and perception, found a significant difference in these auditory abilities of good and poor readers among a group of second and third grade children. He reported also that the extent to which hearing loss was a handicap to the children studied depended largely upon the method—look-and-say or phonetic—by which they had been taught to read.

The present study was initiated, primarily, because of the dearth of information regarding the relation of auditory factors and reading attainment. It has dealt with only one auditory function—acuity. Other factors such as pitch discrimination, auditory span, and auditory memory may be more significantly related to the reading process than is acuity *per se*, but at least keenness of hearing can be measured scientifically, while standardized tests for other aspects of the auditory function cannot be given so successfully to children of elementary school age. Although investigation of the relationship between auditory acuity and progress in reading was the paramount purpose of the study, the scope of the problem included a study of children's audiograms in relation to age, sex, external otological defects, and economic status.

The Maico D 5, an audiometer with a range of 10 frequencies, 128, 256, 512, 1024, 2048, 2896, 4096, 5792, 8192, and 11,584, was used for collecting the hearing data. Preliminary to the investigation proper the instrument was checked at the National Bureau of Standards.[1] What seemed to be an optimum method of obtaining auditory thresholds for children was determined prior to the testing proper. One person gave all of the hearing tests. Left and right ear tests were secured for 295 children; and retests for 262 of these. A room that was quiet rather than sound proof was used for the testing.

External otological examinations were made for 282 of the children by the same physician. The examination in every case was given within a few weeks of the hearing test. Conditions of the throat, ear canals, tympanic membranes, nose, and teeth were noted.

The *Progressive Achievement Test*, and *Gates Primary Reading Test*, Types 1, 2, and 3, were used to determine level of reading. The *Progressive Achievement Test* was given to Grades 2 through 6, and *Gates Primary*

[1]It was also re-checked by the Bureau after the period of testing and found to have remained well within the accepted margin of accuracy.

Reading Test to the first grades. A total of 287 children, 143 males and 144 females, were given these tests. *Durrell's Analysis of Reading Difficulty* was then given to those children through the grades whose reading quotients were lower than 100. Ninety-eight children were given the analytical test.

Statistical treatment of the data obtained in this manner reveals significant information.

Children's Audiograms

A study of the thresholds of audibility shows that children of an ordinary school population vary significantly in their abilities to hear audiometer tones. A child's acuity may vary from one tone to another, and from test to retest. Children as a group hear some tones better than other tones. Correlations between left and right ear show varying degrees of similarity at the different frequencies. Left versus right ear correlations vary from a low of .36 for the 128 tone to a high of .58 for the 2048 tone. Apparently, the acuity for the 2048 tone is more likely to be the same for both ears than is any other tone. Correlations between test and retest vary from .58 left ear and .56 right ear for the 128 tone, to .85 left ear and .82 right ear for the 11,584 tone. Correlations for the high tones, beginning with the 4,096, are higher for each ear than are correlations for tones below the 4,096 frequency. The first test is slightly better than the retest for all frequencies.

For the total population combined left and right ear mean scores show a steady decline in acuity from the 128 tone through the 1024 tone; a pronounced rise at the 2048 tone followed by a drop to approximately the 1024 level at both the 2896 and 4096 tones; and a steady decline from the 5,792 through the 11,584 tones.

For the 4096, 5792, 8192, and 11,584 tones girls hear better than boys. Their hearing scores are less variable than are those for the boys for tones 4096 and 5792; but more variable on the 2048 tone.

In order to reduce the number of variables to as few as possible a factor analysis was done of the hearing scores on the 10 tones. This analysis revealed three significant tone regions: low, medium, and high. This of course suggested that factors associated with loss at one region might be connected in no way with loss at either of the other regions—that is, factors might be operating independently to bring about low, medium, or high-tone loss. Scores for the 128 and 256 frequencies, both ears, were summed for the low-tone factor score, *A*; loss at the 2048 and 2896 frequencies, both ears, were summed for the medium-tone factor score, *B*; and loss at the 8192 and 11,584 frequencies, both ears, were summed for the high-tone factor score, *C*.

Reliability coefficients for these three factor scores were: *A* .91; *B* .92; *C* .93. The *A, B,* and *C* factor scores provided the basis for subsequent study of hearing loss in relation to age, sex, otological defects, economic status, and reading attainment.

The differences in mean loss and variability for the population studied show that significant differences exist in mean loss and variability at the low, medium, and high-tone regions. There is virtual certainty that *C* loss will be greater and the scores more variable than either *A* or *B* scores; that *B* loss will be greater than *A* is reliable within the 1 per cent limits; and that *B* scores will be more variable than *A* is reliable within the 5 per cent limit. Seemingly, more factors are operating to bring about high-tone loss than are operating to bring about medium or low-tone loss; and consequently it might be assumed that factors associated with high-tone losses are more difficult of isolation and study than are those associated with low or medium-tone loss. Causes for *B* loss in comparison to *A* loss would likewise seem to be more numerous.

Sex differences in mean loss at the low and medium tones are negligible. High tone mean loss for boys, however, is reliably greater than high tone mean loss for girls. The only reliable sex difference in variability occurs for the middle tones. For these tones the girls' scores are more variable. These sex differences suggest that, while high-tone loss is greater for boys than girls, factors connected with high-tone loss are as numerous for one sex as for the other; and while boys and girls hear *B* tones equally well, more factors condition the girls' loss for *B* tones than condition the boys' loss for *B* tones.

The data show no reliable age differences. For the population studied hearing loss among children of the elementary grades is independent of age for low, medium, or high tones.

External Otological Examinations

A study of the external otological defects was undertaken to account, if possible, for some of the differences in audiograms. Tabulations show that certain otological conditions are associated with hearing loss at each of the three significant frequency regions. Children with defective throats and defective tympanic membranes have more low-tone loss, 5 per cent reliability, than children without these defects. Those with defective tympanic membranes have reliably more middle-tone loss than children have who are without this defect; and children with defective nasal passages have more middle-tone loss, 1 per cent reliability. Defective tympanic membranes constitute the only otological defect reliably related, 5 per cent limit, to high-tone loss.

Defects of the tympanic membrane bear a highly significant relationship to general (combined *A*, *B*, and *C*) hearing loss; defective throats and left ear canal have a relationship to general loss within the 1 per cent reliability limit; and defective nasal passages and teeth have a relationship to general loss within the 5 per cent limit.

Children in the poorest *A*, *B*, and *C* hearing groups, and in the poorest total loss (*A*, *B*, and *C* combined) hearing groups average more otological defects than do children in the best hearing groups. Those in the poorest hearing groups average a greater number of defects than are averaged by children in the total population; and children in the best hearing groups average fewer defects than do those in the total population.

When children in the best and poorest low, middle, and high-tone hearing groups are compared for percentage differences, the only reliable difference occurs for the best and poorest high-tone groups. The percentage of children with defective throats in the poorest *C* group is reliably (5 per cent limit) higher than is the percentage of children with defective throats in the best *C* group. Again when the best and poorest total-loss groups are compared for percentage differences, the only difference approaching reliability is in connection with defective throats.

Although certain associations certainly exist, the only relationship of a possibly causal nature found between otological defects and hearing loss—for the children involved and within the limits of the statistical treatment employed—is between general hearing loss and the condition of the throat. The fact that there are those associations, however, leads to the surmise that the relationship, incidental or otherwise, may be of importance to education. Factors operating to bring about hearing loss must also be operating to multiply the child's handicaps. Matters such as inadequate nutrition, and parental indifference toward the correction of defects—indifference probably stemming from ignorance—are logically among the factors that might be accountable. Since children from relief families have more general loss (5 per cent reliability) than children from better homes this suggestion seems more than hypothetical.

Achievement in Reading

Reading attainment was studied in connection with low, medium, and high-tone loss. There were 62 cases with reading quotients from 52 to 89; 127 cases from 90 to 109; and 98 cases from 110 to 145.

The mean difference in low-tone loss is negligible for the best and poorest readers, but the best have reliably less variable low-tone scores (*CR* 4.16)

than the poorest. The mean difference in middle-tone loss, in favor of the best readers, is reliable within the 5 per cent limit; and there is a high degree (*CR* 4.26) of certainty that their *B* scores are less variable. The best readers hear high tones reliably (*CR* 3.62) better than the poorest readers hear them. The best readers' *C* scores are also less variable than are the poorest readers' *C* scores (5 per cent reliability).

Reading quotient differences for children with the least and with the most *C* loss are significant. There were 73 children with *C* loss ranging from 0-20 decibels, and 73 with *C* loss ranging from 70-260. The mean *RQ* difference for the two groups is 10.62 points, with a *CR* of 3.80, which shows that the difference although small is highly reliable. In the best *C* group of children only 8 (1^+ per cent) have *RQ*'s below 90, and 36 (49^+ per cent) have *RQ*'s 110 or better. In the poorest *C* group there are 25 children (34^+ per cent) whose *RQ*'s are below 90, and 18 (24^+ per cent) whose *RQ*'s are 110 or above. The *CR* of the difference in these per cents indicates that for a child in the best *C* hearing group the chances are reliably better for him to be an excellent reader than for him to be a poor reader; that his chances for being an excellent reader are reliably better than are the chances for a child in the poorest *C* hearing group. The child in the poorest *C* hearing group, however, has an approximately equal chance of attaining excellent reading that he has for attaining poor reading. Definitely, keen high-tone hearing is accompanied by good reading, and just as definitely some children are able in some manner to compensate for high-tone loss.

Since there is lack of evidence as to the relative importance of monaural and binaural hearing, "worst spots" and "best spots" were studied to see if there appeared to be a functional compensation—at least from the standpoint of reading—for loss at the medium and high frequencies. Loss for 2048 and 2896 frequencies, both ears, had been combined for a medium-tone score and the 8,192 and 11,584, both ears, for the high-tone score. The score of the four at each region representing the least decibel loss was designated the "best spot," at *B* and *C* respectively; and the score representing the greatest loss, the "worst spot." There were 92 cases with "worst spot" at *C* ranging from 0 to 10 decibels, and 67 cases with the "worst spot" ranging from 30 to 90 decibels. The difference in mean reading quotients for these two extreme groups is only 9.34 *RQ* points, but the *CR* of the difference is 3.38, a highly reliable ratio. This indicates that children having a slight amount of loss in either ear at either of the high frequencies will have higher reading quotients than children with a great deal of loss in either ear at either of the frequencies.

A comparison of the "worst spot" and the "best spot" at *C* for the poorest and best readers showed that the "worst spot" differentiates the extreme reading groups more reliably than does the "best spot," with critical ratios of 3.80 and 2.53 respectively.

While *B* loss was found not to bear so close a relationship to reading attainment as *C* loss, there was some association and for that reason "best" and "worst" *B* spots were computed for the extremely good and extremely poor reading groups. As with *C*, the "worst spot" at *B* differentiated the groups more reliably than "best spot," with critical ratios of 2.34 and 1.31 respectively. These results definitely raise the question of how much unilateral or bilateral compensation can be expected with regard to children's hearing.

Since males had more high-tone loss that females, and high-tone loss was found to be significantly connected with reading attainment, reading quotients were studied for sex differences. In the total population (143 boys and 144 girls), girls' reading quotients were higher than those of the boys. For the latter the mean quotient was 96.62, while it was 107.49 for the girls. The critical ratio of this difference was 5.84, a highly significant difference. In the superior reading group, 70 are girls and 28 are boys. In this group of excellent readers the girls' mean *C* score is 15.50 decibels better than that of the boys, with a *CR* of 2.06 (5 per cent reliability). In the poorest reading group 46 are boys and 16 are girls. The mean loss for the girls in this group is 11.40 decibels greater than for the boys, but the difference is not reliable. Thus, in the best reading group the boys' *C* hearing approaches the keenness of the girls' in that group more reliably than for the population as a whole; and in the worst reading group the girls' *C* hearing is just as poor as high tone hearing of the boys in the group—which is not true for the entire population.

In the keenest *C* hearing groups (loss ranging from 0-20) 25 are males and 48 are females; in the poorest *C* hearing groups (loss ranging from 70-260) 25 are females and 48 are males. The critical ratios of these differences in per cents of males and females in these extreme groups are reliably in favor of more girls than boys having keen hearing, and more boys than girls having poor hearing. The difference in per cents of males and females having "worst spots" at *C* that are keen are reliably in favor of the girls; the difference in per cents having "worst spots" that are very poor are reliably in favor of more boys than girls having very poor "worst spots."

From this study it would certainly seem that for the population under

consideration high-tone hearing loss is one of the causes of reading deficiency, even that poor reading might be viewed as symptomatic of high-tone loss. Nonetheless there are some children with keen high-tone hearing who fail to achieve in reading just as there are many with high-tone loss who achieve average or above average in their reading. For this reason, the relationship that has been shown to exist between reading development and high-tone loss should be considered a phenomenon applicable to group rather than individual prognosis.

Although hearing for high-tones and reading achievement appear to be causally related, certain possible explanations for the association should be critically evaluated. It has been shown that for the population studied otological defects are more prevalent among those with hearing loss, and that children of low economic status have more hearing loss than the children from better homes. Therefore it seems reasonable to conclude that children handicapped with hearing difficulties frequently have additional defects that may mitigate against school progress. If the child with incomplete hearing has otological infections that are a drain on his vitality, if he is undernourished and fatigues easily, and if, in addition, his intelligence is below normal, his handicaps may be insurmountable for school success. On the other hand, the child whose hearing is deficient may have vitality, ambition, and intelligence to balance his hearing handicap. The age of the onset of hearing difficulties as well as the degree of loss are no doubt further factors in determining the extent to which hearing loss is a functional handicap. While all of these considerations should be taken into account in interpreting the relationship between hearing loss and school progress, they do not readily explain why a closer association is found between the high-frequency hearing and reading achievement than is found between medium-frequency hearing and reading achievement.

The question has been raised elsewhere in this paper as to whether intelligence as measured by tests might not be connected with high-tone loss. Since there is a positive relationship between reading test scores and intelligence test scores this relationship seems possible. It is also usually accepted that tests of language abilities in general are more closely related to intelligence test scores than are other sorts of abilities. Hence, it seems plausible to consider the possibility that successful development of language abilities other than reading may be dependent to some extent upon keenness of hearing for high tones. Basic to the reasonableness of these possibilities is the fact that the sense of hearing is an important medium for learning. The development of intelligence itself is affected by the acuity of the various senses. This

does not mean that sense acuity alone is sufficient. Translation of sense stimuli into meaningful associations is a central phenomenon, but accurate translation is influenced by the completeness of peripheral response. Consonant sounds are created by relatively higher frequency pressure patterns than are the vowel sounds; they are relatively softer and are dissipated more quickly. In addition, they carry relatively more of the intelligibility of speech and in spoken English they occur more often than the vowels (24, p. 132).

How much loss for the high frequencies can be sustained without interrupting the precision of hearing the consonant sounds is not known. An audiometric hearing test determines the level of hearing response in relation to what is accepted as normal threshold response, and certainly "we do not live in a world of threshold sounds." Consonants carry less pressure power than vowels, and some consonants carry less than other consonants, but all carry pressure that is above threshold.

Evidence that the frequencies above the 2000 or 4000 levels are of less importance for the interpretation of speech sounds than are the frequencies below 2000 or 4000 cycles is based on results of articulation tests given to adult subjects under laboratory conditions. For children it is quite possible that the high frequencies are of equal or perhaps greater importance for precise interpretation of speech sounds. The child is hearing new words daily, many of which carry no visual association for him. He may also be hearing new words, which, because they are new in his experience, carry no sort of associative meaning. An adult does not always need to hear completely what is being said because his experience can fill in many sounds that his ears miss. The more limited knowledge and experience of the child may result in the misinterpretation of sounds that his ears have failed to distinguish accurately.

If this hypothesis is correct—that acute hearing for the high frequencies, because of the nature and importance of the consonant sounds, is of more importance to the child than is acute hearing for the low and medium frequencies—then the values of the high frequencies for vocabulary and reading progress are evident. The significant relationships that this study has found between excellent reading and keen hearing for the high tones and between poor reading and high-tone loss lend support to the theory.

References

1. American Standards Association. Purposed Minimum Specifications for Audiometers for General Diagnostic Purposes, Z 24.5, as revised Dec. 1, 1937. New York: American Standards Association (no date).
2. ———. American Standard Accoustical Terminology, Z 24.1-1942, approved March 20, 1942. New York: American Standards Association (no date).
3. Baehne, G. W. Practical Applications of the Punched Card Method in Colleges and Universities. New York: Columbia Univ. Press, 1935.
4. Beatty, R. T. Hearing in Man and Animals. London: Bell, 1932.
5. Bennett, C. C. An Inquiry into the Genesis of Poor Reading. Teach. Col., Contrib. Ed., No. 755. New York: Columbia Univ., 1938.
6. Berry, G. Deafness in the United States (A statistical review). *Volta Rev.*, 1938, **40**, 69-71.
7. ———. Hearing and hearing-aids: A review of the recent literature. *Laryngoscope*, 1942, **52**, 143-64.
8. Best, H. Deaf and Deafness in the United States. New York: Macmillan, 1943.
9. Betts, E. A. Prevention and Correction of Reading Difficulties. Evanston, Ill.: Peterson, 1936.
10. Bond, G. L. The Auditory and Speech Characteristics of Poor Readers. Teach. Col., Contrib. Ed., No. 657. New York: Columbia Univ., 1935.
11. Bunch, C. C., & Raiford, T. S. Race and sex variations in auditory acuity. *Arch. Otolaryngol.*, 1931, **13**, 422-434.
12. California Test Bureau. Monual of Directions, Progressive Achievement Tests, Primary Battery, 1937 Revised Norms, Forms A, B, and C. Los Angeles, California: California Test Bureau (no date).
13. ———. Manual of Directions Progressive Achievement Tests, Elementary Battery 1937 Revised Norms, Forms A, B, and C. Los Angeles, California: California Test Bureau (no date).
14. Carter, H. A. Review of methods used for estimating percentage loss of hearing. *Laryngoscope*, 1942, **52**, 379-90.
15. Ciocco, A. Audiometric Studies of School Children: II. Types of Audiometric Curves, Reprint No. 1784, Public Health Reports, Vol. 51, No. 47, Nov. 20, 1936. Washington D. C.: U. S. Printing Office 1937.
16. Cotton, J. C., & Hall, J. Administration of 6A Audiometer Tests to kindergarten and first grade children. *Volta Rev.*, 1939, **41**, 291-292 and 312-314.
17. Conway, C. B. The Hearing Abilities of Children in Toronto Public Schools. Ontario Col. of Ed., Department of Ed. Res., Bull. No. 9. Toronto: Univ. Toronto Press, 1937.
18. Crandall, J. B. The composition of speech. *Physical Rev.*, 1917, **10**, 221-232.
19. ———. The sounds of speech. *Bell System Tech. J.*, 1925, **4**, 586-626.
20. ———. Dynamical study of the vowel sounds: Part II. *Bell System Tech. J.*, 1927, **6**, 100-116.
21. Crandall, J. B., & Mackenzie, D. Analysis of the energy distribution in speech. *Physical Rev.*, 1922, **19**, 221-232.
22. Crowe, S. J., *et al.* Impaired hearing in school children. *Laryngoscope*, 1942, **52**, 790-804.
23. Curry, L. T. What is a mastoid. *Hygeia*, 1936, **14**, 48-49.
24. Dewey, G. Relative Frequency of English Speech Sounds. Harvard Studies in Ed., No. 4. Cambridge, Mass.: Harvard Univ. Press, 1923.
25. Durrell, D. D. Manual of Direction of Analysis of Reading Difficulty. New York: World, 1937.

26. FILDES, L. G. A psychological inquiry into the nature of the condition known as congenital word blindness. *Brain; J. J. Neurol.*, 1921, **44**, 286-307.

27. FISHBEIN, W. L. The child's ears. *Hygeia*, 1940, **18**, 370-372.

28. FLETCHER, H. Dependence of loudness of a complex sound upon the energy in the various frequency regions. *Phys. Rev.*, 1924, **24**, 306-318.

29. ———. Articulation testing methods. *Bell System Tech. J.*, 1929, **8**, 806-854.

30. ———. Some physical characteristics of speech and music. *The Bell System Tech. J.*, 1931, **10**, 349.

31. ———. Newer concepts of the pitch, loudness, and timbre of musical tones. *Bell System Tech. Pub., Acoustics Monograph* B-896, 1935.

32. ———. Speech and Hearing. New York: D. Van Nostrand, 1936.

33. FLETCHER, H., & STEINBERG, J. C. Articulation Testing Methods. *J. Acoust. Soc. Amer.*, 1929-31, **1** and **2**, 1-97.

34. FLETCHER, H., & WEGEL, R. L. The frequency-sensitivity of normal ears. *Physical Rev.*, 1922, **19**, 553-565.

35. FOLEY, A. T. College Physics. Philadelphia: Blakinston, 1933.

36. FOWLER, E. P. A simple method of measuring percentage of capacity for hearing speech. *Arch. Otolaryngol.*, 1942, **30**, 874-880.

37. FREEMAN, G. L. Introduction to Physiological Psychology. New York: Ronald Press, 1934.

38. GARDNER, W. H. Speech and Hearing Defects. *J. Indiana State Med. Assn.*, 1939, **32**, 105-108.

39. ———. Report of the Committee on Hard of Hearing Children of the American Society for the Hard of Hearing for the School Year 1937-38, Pamphlet No. 122. Washington, D. C.: American Society for the Hard of Hearing, 1939.

40. ———. Report of the Committee on Hard-of-Hearing Children of the American Society for the Hard of Hearing for the School Year 1938-39. Proceedings: 21st Annual Meeting. Washington, D. C.: American Society of the Hard of Hearing, 1940.

41. ———. Hard of hearing children. *J. Sch. Health*, 1940, **10**, 22.

42. ———. Getting results in hearing tests. *Volta Rev.*, 1934, **36**, 359-361.

43. GARRETT, H. E. Statistics in Psychology and Education. New York: Longmans, Green, 1941.

44. GATES, A. I. Diagnosis and Treatment of Extreme Cases of Reading Disability. *Thirty-Sixth Yearbook of the National Society for the Study of Education*, Part I. Bloomington, Ill.: Public School Publishing Company, 1937. (Pp. 391-415.)

45. ———. The Improvement of Reading. New York: Macmillan, 1936.

46. ———. The necessary mental age for beginning reading. *El. Sch. J.*, 1937, **37**, 497-508.

47. ———. Manual for Directions for Gates Primary Reading Tests. New York: Col. Univ. Bureau of Pub., 1939.

48. GATES, A. I., & BOND, G. L. Reading readiness: A study of factors determining success and failure in beginning reading. *Teach. Col. Rec.*, 1936, **27**, 679-685.

49. GOOD, C. V., BARR, A. S., & SCATES, D. E. The Methodology of Education Research. New York: D. Appleton, 1936.

50. GOLDSTEIN, M. A. Defective speech in relation to defective hearing. *Arch. Otolaryngol.*, 1940, **31**, 38-40.

51. GUILFORD, J. P. Psychometric Methods. New York: McGraw-Hill, 1936.

52. ———. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill, 1942.

53. HINCKS, E. M. Disability in Reading and Its Relation to Personality. Harvard Univ. Monographs in Ed., No. 7. Cambridge: Harvard Univ. Press, 1926.

54. HUNT, W. M. What is being done for the deafness of school children. *Laryngoscope*, 1942, **52**, 230-241.

55. JONES, A. T. Sound, A Text Book. New York: Van Nostrand, 1937.

56. KARLIN, J. E. Music ability. *Psychometrika*, 1941, **6**, 61-65.

57. ———. A factorial study of auditory function. *Psychometrika*, 1942, **7**, 251-297.

58. KELLEY, J. B. Finding the hard-of-hearing child. *Pub. Health Nursing*, May, 1938.

59. KOBRAK, H. G., LINDSAY, J. R., & PERLMAN, H. B. Experimental observations on auditory masking. *Laryngoscope*, 1942, **52**, 870-878.

60. LEE, J. E. A new challenge in education. *Volta Rev.*, 1938, **40**, 261-263.

61. LEHMAN, R. Johnny, are you deaf? *Hygeia*, 1935, **13**, 1026-1028

62. MACNUTT, E. Group Hearing Tests by Means of the 4A or Phonograph Audiometer, Pamphlet No. 107. Washington, D. C.: American Society for the Hard of Hearing (no date).

63. ———. Three milllion strain their ears. *J. Educ.*, 1935, **118**, 416, 418.

64. ———. Is your child hard of hearing? *Volta Rev.*, 1935, **37**, 353-384.

65. MADDEN, R. M. The School Status of the Hard-of-Hearing Child. Teach. Col., Contrib. Ed., No. 499. New York: Columbia Univ., 1931.

66. MAICO COMPANY, INC. Audiometers. Minneapolis, Minn.: Maico (no date).

67. ———. Manual for Audiometers. Minneapolis, Minn.: Maico (no date).

68. MILLS, J. A Fugue in Cycles and Bels. New York: D. Van Nostrand, 1935.

69. MONROE, M. Children Who Cannot Read. Chicago: Univ. Chicago Press, 1932.

70. MONROE, W. S., ed. Encyclopedia of Educational Research. New York: Macmillan, 1941.

71. MONTGOMERY, H. C. The measurement of differential intensity sensitivity of the ear. *Bell Telephone System Tech. Pub.*, Acoustics Monograph B-878, 1935.

72. ———. Analysis of World's Fair's hearing tests. *Sci. Mo.*, 1940, **50**, 335-339.

73. MORSE, P. M. Vibration and Sound. New York: McGraw-Hill, 1936.

74. NATIONAL HEALTH SURVEY, 1935-1936. Hearing Study Series, Bulletin No. I. Significance, Scope and Methods of a Clinical Investigation of Hearing in the General Population. Washington, D. C.: U. S. Pub. Health Service, Division of Public Health Methods, 1938.

75. ———. Bulletin No. 2. Preliminary Analysis of Audiometric Data in Relation to Clinical History of Impaired Hearing.

76. ———. Bulletin No. 3. Prevalence of Aural Pathology and Clinical History of Impaired Hearing Among Males and Females of Various Ages.

77. ———. Bulletin No. 4. Normal Hearing by Air and Bone Conduction.

78. ———. Bulletin No. 5. Normal Hearing for Speech at Each Decade of Life.

79. ———. Bulletin No. 6. Sex Differences and Age Variation in Hearing Loss in Relation to Stage of Deafness.

80. ———. Bulletin No. 7. Generalized Age and Sex Trends in Hearing Loss.

81. NEUSCHUTZ, L. M. Helping hard-of-hearing pupils. *Hygeia*, 1939, **71**, 1145-1146.

82. ORR, F. W. Voice for Speech. New York: McGraw-Hill, 1938.

83. ORTON, S. T. Reading, Writing and Speech Problems in Children. New York: Norton, 1937.

84. RICHARDSON, E. G. Sound: A Physical Text Book. London: Arnold, 1935.

85. SACIA, C. F., & BECK, C. J. The power of fundamental speech sounds. *Bell System Tech. J.*, 1926, **5**, 393-403.

86. SEASHORE, C. E. Psychology of Music. New York: McGraw-Hill, 1938.

87. SNOW, W. B. Change in pitch with loudness at low frequencies. *Bell Telephone System Tech. Pub.*, Acoustics Monograph B-919, 1936.

88. STANLEY, D. The Science of Voice. New York: Fischer, 1929.

89. STEINBERG, J. C. Effects of distortion upon the recognition of speech sounds. *J. Acoust. Soc. Amer.*, 1929, **1** and **2**, 121-136.

90. ———. Applying sound measuring instruments to the study of phonetic problems. *Bell Telephone System Tech. Pub.*, Acoustics Monograph B-820, 1934.

91. STEINBERG, J. C., & MUNSON, W. A. Deviations in the loudness judgments of 100 people. *Bell Telephone System Tech. Pub.*, Acoustics Monograph B-967, 1936.

92. STERLING, B., & BELL, E. Hearing of School Children as Measured by the Audiometer and as Related to School Work, United States Public Health Service, Health Reports, Vol. 45, No. 20. Washington, D. C.: U. S. Government Printing Office, 1930.

93. STEVENS, S. S., & DAVIS, H. Hearing, Its Psychology and Physiology. New York: Wiley, 1938.

94. STEVENS, S. S., & VOLKMANN, J. The relation of pitch to frequency: A revised scale. *Amer. J. Psychol.*, 1940, **53**, 329-353.

95. STEVENSON, R. S. Recent Advances in Laryngology and Otology. Philadelphia: Blakiston, 1935.

96. TERMAN, L. M. Genetic Studies of Genius: Volume I. Mental and Physical Traits of a Thousand Gifted Children. Stanford Univ., California: Stanford Univ. Press, 1925.

97. THURLOW, W. R. Studies in auditory theory: I. *J. Exp. Psychol.*, 1943, **32**, 17-36.

98. TRAXLER, A. E. Ten years of research in reading: Summary and bibliography. *Educ. Rec. Bull.*, 1941, No. 32.

99. United States Office of Education, Federal Security Agency. Rehabilitation of the Deaf and the Hard of Hearing, A Manual for Rehabilitation Case Workers, Vocational Rehabilitation Series, Bulletin No. 26. Washington, D. C.: U. S. Government Printing Office, 1942.

100. VOORHEES, I. W. What did you say? *Hygeia*, 1939, **17**, 296-298.

101. WALDMAN, J. L., WADE, F. A., & ARETZ, C. W. Hearing and the School Child: Hearing, School Progress and Achievement of Public School Children. Philadelphia: Temple Univ. Press, 1930.

102. WATERS, F. A. The hard-of-hearing child in the parochial school. *Volta Rev.*, 1934, **36**, 613-615.

103. WATSON, F. R. Sound: An Elementary Textbook on Sound and the Phenomena of Hearing. New York: Wiley, 1935.

104. WEGEL, R. L., & LANE, C. E. The auditory masking of one pure tone by another, etc. *Physical Rev.*, 1924, **23**, 266-285.

105. WEST, R. Speech and hearing. *Volta Rev.*, 1935, **37**, 573-578 and 626-628.

106. WHITE HOUSE CONFERENCE. Special Education: The Handicapped and the Gifted. New York: Century, 1931.

107. WILSON, F. T., & BURK, A. Reading readiness in a progressive school. *Teach. Col. Rec.*, 1937, **38**, 565-580.

108. WILSON, F. T., & FLEMMING, C. W. Correlation of reading progress with other abilities and traits of Grade I children. *J. Genet. Psychol.*, 1938, **53**, 35-52.

109. WILSON, F. T., *et al.* Reading progress in kindergarten and primary grades. *El. Sch. J.*, 1938, **38**, 442-449.

110. WOODWORTH, R. S. Experimental Psychology. New York: Holt, 1938.

111. WRIGHT, W. W. The Nature and Measurement of Reading Readiness. Newer Practices in Reading in the Elementary School, Seventeenth Yearbook of the National Elementary Principal of the N.E.A. July, 1938. (Pp. 248-52.)

112. YOUNG, W. E. Relation of reading comprehension and retention to hearing comprehension and retention. *J. Exp. Ed.*, 1936, **5**, 30-39.

State Teachers College
Farmville, Virginia

The Journal of Genetic Psychology, 1947, 71, 65-73.

DO WE GROW MENTALLY?*

Central Michigan College of Education

OSCAR OPPENHEIMER

The results of modern research in the fields of genetic psychology and of psychology of personality, impressive as they are, appear even more impressive when we consider that they have been accomplished without a clear understanding of the basic concepts involved. That means we have been penetrating deeply a world of facts by using tools the true nature of which we do not know. In doing this we resemble the factory worker who pushes the button to make the machine run, without being able to say how it can run. The two basic concepts which we have been using all the time this way are development and growth. I have scanned a large number of books which employ the terms continually, but I have not found any satisfactory description or definition of them.

The term development is the broader of the two terms. It suggests two things: a continuous process leading from a less to a more complete stage, mostly by way of intermediary stages, and secondly, a rise in value from a lower to a higher level. The term growth, while it carries the second feature in about the same manner as development does, gives a very specific interpretation to the first feature. The process leading from a less to a more complete stage is understood as a process of self-development; that is, the seed develops into a tree in a way in which the influence of environment is very secondary to a force coming out of the seed and directing what we call growth. From Aristotle's entelechie to Bergson's élan vital, we have labored to understand this mysterious force. Sometimes we have deceived ourselves by feeling content with giving it a new name. Other times we have denied its existence and have tried in vain to replace it by mechanistic cause and effect. There is no need for us in the compass of this paper to enter the debate on the nature of growth. For this paper is mainly devoted to the task of demonstrating that growth (and development) do not take place in the mental field except in minor phenomena. So the detailed interpretation of growth is irrelevant to our discussion. Before we go into the discussion, the curious reader may ask why, if our contention is true that there is so little growth and development in the mental field, both terms

*Received in the Editorial Office on April 7, 1946.

have been used so profusely. The answer is plain: Both terms have their legitimate places in the field of biology, and because the body is intimately connected with the mind, terms of the one field have been applied to phenomena of the other, particularly in cases of psychologists who deny a difference in the nature of the two fields.

In the realm of intelligence the two terms have been used very widely, mainly because the phenomenon of knowledge has barred the view at the true facts. I like to start a discussion with a combination of definitions of intelligence by two of the finest students of the subject, Thorndike and Spearman. While Thorndike defines intelligence as a combination of learning and memory, Spearman defines it as a grasping of relationships. Substituting learning by the more descriptive term "grasping of relationships," we would say that intelligence consists of grasping of relationships plus memory. When we grasp relationships and entrust them to memory, we acquire knowledge. The place of knowledge in the field of intelligence is a very interesting one. It is very clearly a result of the use of intelligence, not a part of intelligence. We can accumulate large amounts of knowledge without any need for development or growth of our abilities to grasp or retain relationships. Furthermore, the older child will be able to absorb more knowledge than the younger one for a very peculiar aspect of knowledge which we call frame of reference. We see the two-year-old child having learned about 300 new words a year, and the six-year-old child having learned twice as much, and we marvel at the apparent development of intelligence, when we should realize that all that makes the difference in performance is the difference in the size of frame of reference. How much more mental effort does the two-year-old need to understand and retain completely or almost completely new words, when the six-year-old in grasping a "new" word is reminded of a number of others similar in sound and meaning. How much "newer" is each word to the smaller child!

What is true in the field of language is true in all other fields of intelligence. The whole process of learning is nothing but a process of continuous application of the same intelligence to an ever larger field of facts with mounting success because of the increase of knowledge along with the growing frame of reference. Two specific phenomena illustrate our case. Some psychologists like Piaget and Goldstein have stressed the difference between concrete and abstract thinking. While it is true that they are pointing at extremely important facts in the field, they overlook that concrete and abstract thinking are not different successive stages in the development of thinking, but are common aspects of any case of thinking. The most primi-

tive thought of the child has both aspects, as well as the intricate thought of the scholar. The small child seeing his father and exclaiming, "This is daddy!" puts this man in front of him into a class to which the daddies of yesterday, of a week ago and of a month ago belong, and can do this only on the basis of a good piece of abstract thinking. The only difference between the child and the mathematician who studies calculus is a difference in the size of the frame of reference. How much do we have to learn until we are ready for calculus! The discussion of abstract thinking gives us an opportunity to clear up a possible misunderstanding: does the fact that our intelligence does not grow, that the only thing becoming larger is our knowledge, indicate that everybody can study calculus? Not at all! Differences in native intelligence may still exist and may be a decisive factor in our attempt to learn calculus. Thus there is no need to assume that this intelligence must grow.

A phenomenon beside concrete and abstract thinking that is very helpful in clarifying our point is the phenomenon of capacity and ability. Woodworth says capacity is what we are able to do, ability is what we are ready to do. Do the facts involved force us to accept a development which advances from a state of capacity to a state of ability? I may have the capacity to understand calculus and yet never acquire the ability. Do we need to conjure up here a mysterious process of development, or is it not enough to say that we never acquired the frame of reference necessary to tackle calculus? A capacity becoming an ability does not grow, an ability is nothing but an applied capacity, and application is possible if the required frame of reference is available.

To summarize our discussion on intelligence: intelligence does not develop or grow, knowledge increases. All that happens through our lives is a greater and greater opportunity to apply the same gift. While the picture that we receive of intelligence this way may appear static as a whole, it does not lack the dynamic features. For it will depend very much on factors such as interests and will power and opportunities and health how much and how little we will use this "static" intelligence, and for this reason the life story of two persons with about the same intelligence may look very different, even if intelligence is robbed of the element of growth.

In regard to our discussion, the rôle which knowledge plays in the field of intelligence is played by secondary motives in the field of motivation. As the acquisition of knowledge in the field of intelligence suggests a development that does not in reality exist, so in the field of motivation secondary motives and their constant change during the lifetime of man

make us believe in a development that is belied by the unchanging existence of primary motives. To illustrate our point: the primary motive of social prestige, appearing early, may be satisfied first by the realization of the secondary motive of striving to outdo brother and sister in the family circle; then by trying to make good grades in school, followed by striving for the captaincy of the football team or the leadership of the gang, replaced later by the attempt to date the prettiest girl, finally by realization of the secondary motives of adulthood, e.g., striving for making much money or acquiring a high position or becoming president of Rotary International. The life story of an individual can be largely told by the history of his secondary motives. But does this indicate mental development? Compared with the primary motives, secondary motives are nothing but means which when realized help realize the primary motives. And these primary motives remain unchanged. Again as in the case of intelligence the picture is one of much dynamic change on the surface, and of static changelessness at bottom. It is the great accomplishment of McDougall and of Freud to have stressed the unaltered nature of primary motives from childhood to old age, and the fact that the detailed description of single motives by these authors often is very inadequate should not prompt us to discount the greatness of that accomplishment. The contention that primary motives do not change is not refuted by the fact that some of them appear long after birth. All the surprising discoveries in the realm of prenatal mental life should caution us against making too much of a fetish of the event of birth in the life of the individual. The salient point for our discussion is that when some primary motives make their first appearance later, they do not appear as a fruit of a long development, but turn up ready as Pallas Athene from the head of Zeus. It is interesting in this context to look at the sex motive. The genuine interest in the other sex awakens in the adolescent accompanied by bodily maturation. Bodily maturation confuses our view and makes us imagine a parallel mental development. A phenomenon with much bearing on this part of our discussion is the disposition for primary motives. A primary motive may be present for a long time only in a latent way, as a disposition, and it requires favorable circumstances to transform the disposition into an actual primary motive. We are prompted to assume the existence of dispositions in the period preceding the actual existence of primary motives, because under identical circumstances a certain primary motive may arise in one individual and not in the other. But, and this is the point revelant to our discussion, the transformation of a disposition into an actual motive is as little an evidence for mental development as the transformation of capacity into ability

is in the intellectual field. In both cases what was latent becomes actual without any resort to time.

In the interpretation of motivation, intelligence does not only furnish elucidating parallel phenomena, it itself plays an important rôle in the field of motivation. For the choice of secondary motives is determined by the intellectual knowledge we have of our environment. The boy who wants to realize the primary motive of social prestige sees that in his present setting the best way of doing it is by the realization of a secondary motive, namely by striving for leadership in the gang. He has acquired the knowledge that that would give him the maximum of social prestige among his mates, while this boy, having become a man, in order to satisfy the same primary motive, will strive for the presidency of Rotary on the basis of new knowledge. So, we see, it is the acquisition of knowledge that not only takes the place of genuine mental development in the intellectual sphere, but is also responsible for most of the surface change in the field of motivation.

What we have learned about the rôle of mental development in motivation in our general treatment of motives, will be corroborated when we look at two more specific aspects of motivation, at its moral quality and at the phenomenon of will. The moral life of man is an up and down of victory and defeat. When altruistic and egotistic motives clash in us, and the altruistic motive becomes victorious, victory gives so much satisfaction because defeat was a possibility, and the stronger the possibility of defeat is, the stronger is the satisfaction of victory. The lack of efforts in successive victories of the saint, if there is such a man, weakens the meaning and strength of a moral decision. In the lives of less saintly humans, the moral curve is irregular and zigzag and void of features which would suggest continuous development. This is also true in regard to the human will. (The students of motivation who deny the existence of the human will as a phenomenon *sui generis* and try to reduce it to a part of thinking, emotions, actions, or motives may wish to skip the next brief passage because the scope of this paper forbids lengthy statements necessary to disprove their point.) Will does not develop either. This may be bad news to the owner of a weak will who is much concerned with the gradual strengthening of his will. If will does not grow, all that he can do is to find tasks suited to the size of his will, and this may prove as effective in a practical manner as a genuine development of his will power would be. But there is a great theoretical difference. When the owner of a weak will knows that he can tackle a certain difficult task with his will because he has a strong interest in this task, and that he cannot do another task of similar difficulty because he

lacks interest in it, then, on the basis of his knowledge, he will choose the first task. Interest is only one of a number of factors influencing the use of will. *But in case of all of them the increase of knowledge makes us fall prey to the illusion of development operating in the field of will.* Knowing when and how to apply our will is the whole story.

By now the reader may have become wary of phenomena which create the delusion of mental development although by their very nature they have nothing to do with it. Therefore, he will no longer be surprised to find a similar situation in the *field of emotions. Emotions do not grow.* The story of emotions in the course of an individual's life is primarily the story of the *expression* of emotions. In the society in which we find ourselves we learn that the expression of many emotions is taboo, and that in the case of other emotions only a mild expression is desired. We may not express fear, hatred, anger, jealousy at all; we may show only weak expressions of many types of affection or of pride. Due to the great strength of many emotions, many individuals are learning here the hard way, and are spending large sections of their lives with efforts in that direction. But here again, the emotions do not develop, all change refers to their exterior expression. And here again as in the case of motives and of will it is the increase of knowledge that holds the place, erroneously given to mental development. We are acquiring more and more knowledge about what our society requires, and we are applying this knowledge to our ways of expressing our emotions.

In summarizing our analysis so far, I would state: As intelligence, motivation, and emotions cover the larger part of the mind, it appears that what we wrongly call mental development is the story of application of our unchanging mental gifts, like intelligence, motives, will, and emotions, to ever changing tasks on the basis of increasing knowledge. We receive the picture of a mind that changes only on its surface.

If I would stop here, the picture would lack important features which continue to bring out how far from the truth an interpretation of mental life in terms of mental development is. While I have analyzed so far phenomena which reveal the absence of mental development, I shall deal now with phenomena which not only demonstrate the absence of mental development, but show even a clear tendency to arresting any such development or a tendency to making impotent part of our mental gifts. The first tendency is present in habits and beliefs, two important factors in our mental household. The function of habits in our lives is to do away more or less with the only faint vestige of mental development which we were able to find. We establish habits in order to escape the time- and effort-consuming

procedure of applying our mental gifts to new tasks on the basis of increased knowledge. With the help of habits we deal with new tasks on the basis of old knowledge, and in ways in which we dealt with similar tasks before. Observing the discrepancy between new knowledge that we should use for mastering new tasks, and the old knowledge that we use by way of habits we sometimes squirm under the tyranny of habits. But generally we rest satisfied with not being called upon to meet a new situation with new means. How strong this inclination to stagnate is in man, becomes even more evident when we analyze beliefs. I like to use as an example the type of beliefs which we call prejudices. The core of each prejudice is two steps of crooked thinking. Swayed by emotions we make first an unjustified generalization, taking traits of single individuals as traits of a group, and after we have done this, we interpret the behavior of new members of the same group. First we see three negroes being shiftless, then we conclude all negroes are shiftless, then we interpret the slightest intimation of shiftlessness in the actions of a new negro as a striking confirmation of our prejudice, or if we find an industrious negro we make light of his industry and treat him as an exception. While habits only prevent us from *applying* new knowledge, beliefs prevent us from the *acquisition* of new knowledge, and so, in view of the large functions of beliefs in our lives, impair considerably the importance of knowledge, and yet, we have seen, knowledge is the only factor which makes for some kind of mental development.

All the many phenomena which demonstrate our inclination to make the use of mental gifts impossible lead us even farther away from mental development. The case of moral decisions is much more a case of keeping the evil motive from becoming realized than it is a case of realizing the good motive. Moral life as a whole presents man as consisting of an evil and a good part, and his task all through life is to prevent the evil part from taking the lead. Here more than anywhere else a notion is led *ad absurdum* which the concept of mental development has often suggested, namely that there is harmony among the gifts which make up the mind, that all of them are only waiting for being developed. The true picture shows just opposite features, the various parts of the mind are put together very inharmoniously, and one can be established permanently only at the expense of the other. In other words: nothing develops, something is kept from developing. The some aspect which we find in man's moral life also is presented in habits. The establishing of good habits, another large part of our business in life, in reality is not the positive activity the term would suggest, but is prevailingly the negative activity of uprooting poor habits. Having uprooted

the poor habit usually means having set up the good habit. We take away more than we add. The same holds true with emotions. We found before that the only fact here which is indicative of development has to do with the expression of emotions. But as we have seen, even our treatment of expression of emotions is more in the direction of checking undesired forms of expression than of encouraging new desirable forms. This is also true in our dealings with emotions themselves. Because society disapproves, we do not want to have emotions like fear, hatred, jealousy, self pity, and we try to get rid of them. Into the vacuum left by them the desirable emotions pour in. The discussion of the ways in which we eliminate undesirable emotions opens up another wide field of phenomena which belie the truth of the concept of mental development. We try to get rid of them, first by suppression, and then a large part of our mental efforts is devoted to attempts at keeping them down and maintaining a precious balance. The host of phenomena like frustration, regression, infantilism, inferiority complex, projection, rationalization, defense mechanisms, etc., bears telling witness to the intensity of the fight in which we are engaged here. The strain, so characteristic of our mental life, is the common result of all of them. Last, but not least, among the many indicators of negative and not "positive" development we find imagination. How far a cry it is from the complete devotion of the small child to an entire world of imagination (a devotion so complete that the imagined world is the real world to the child) to the suspicion with which the adult looks at the miserable shreds of imagination left after his violent battle to stamp it out, so violent a battle because he thinks it will sap his strength in the struggle with the hard facts of the real world. Again we destroy, we do not develop.

Our discussion of mental development would be incomplete without including a treatment of the concept of mature personality. Up to now we have been mainly concerned with the aspect of development which, at the beginning of this paper, I presented as its first feature, namely, development being a process from a less to a more complete stage. The term maturity of personality (and its opposite, immaturity, perhaps even more) connotes more strongly my second feature of development, the value feature which holds that development means a rise from a lower to a higher level. For our treatment of the mature personality it will be profitable to take Allport's study of the subject as a basis since it is the most thorough study I know. He considers intelligent planning for the future, a unifying philosophy of life, and self-objectification earmarks of a mature person. It looks to me as though all three of them fit perfectly into our scheme of application of

our gifts to new tasks on the basis of increased knowledge. The difference between a mature and a less mature person is a difference of degree of knowledge. The mature person has reached the point in acquisition of knowledge where he can tackle almost any new task which may turn up in his world. He is able to plan intelligently for the future because this future very probably will not hold problems which he could not solve on the basis of his present knowledge, and for the same reason he can develop a unifying philosophy of life. The third feature of Allport's mature personality, self-objectification, has its basis in a similar situation. Because the mature personality knows so much, he cannot overlook his own limitations. Being able to appraise possible tasks and the gifts of his fellowman, he cannot fail seeing his inability to accomplish some of the tasks, and his inferiority to some of his fellows. Thus all those characteristics of mature personality, and mature personality itself, are not fruits of a development of the mind as a whole. All parts of the mind but one have remained unchanged, and the one that has changed, namely knowledge, is a very extraneous part. This is the basis of maturity, and after having said that much, I am ready to admit that in a mature person certain attitudes have undergone a change. A mature person does not jump into a new task with two feet, warily he consults his knowledge first; a mature person does not try the impossible, and a mature person is capable of looking at himself with humor because he realizes his limitations. All such attitudes distinguish him from the immature person. But all of them, it is easy to note, stem from the increase in knowledge that forms the foundation of his being a mature person.

We have tried to show that the concept of mental development (and growth), so widely used in modern psychology, should be used with great caution, as it applies only to a restricted and extraneous section of the mind, while a much larger section of the same mind abounds in phenomena of a nature indifferent or hostile to the concept of development.

References

1. Allport, G. W. Personality. New York: Holt, 1937. (Ch. 8.)
2. Goldstein, K., & Scheerer, M. Abstract and Concrete Behavior. *Psychol. Monog.*, 1941, 53, No. 239.
3. Piaget, J. Judgment and Reasoning in the Child. New York: Harcourt, Brace, 1928.
4. Spearman, C. The Abilities of Man. New York: Macmillan, 1927.
5. Thorndike, E. L. The Measurement of Intelligence. New York: Columbia Univ. Press, 1925.

Central Michigan College of Education
Mount Pleasant, Michigan

The Journal of Genetic Psychology, 1947, 71, 75-84.

LATERAL PREFERENCES OF A GROUP OF MENTALLY SUBNORMAL BOYS*

Department of Psychology, College of the City of New York

Alexander Mintz

Incidentally to research of a different nature, the handedness and sighting preference (often called "eyedness" in the literature) of a group of boy inmates of an institution for the feebleminded were determined. The distribution of the lateral preferences was markedly different from those generally obtained with normal subjects; it had features in common with distributions obtained with various abnormal groups. The work was done in the early part of the year 1931, and an incomplete analysis of the data was reported at the meeting of the New York Branch of the American Psychological Association in 1933. Inasmuch as a survey of the literature indicated that the results are not out of date, it was thought that publication of the material would be desirable.

Subjects and Procedure

The subjects of this study were 97 boys from Letchworth Village, a New York State institution for the feebleminded. All of them attended the school maintained by the institution. Their ages ranged from 7 yrs., 11 mos. to 17 yrs., 3 mos.; their Stanford Binet *IQ*'s[1] ranged from 47-87. The distribution of the *IQ*'s was as follows:

Below 50:	2
50-59:	18
60-69:	47
70-79:	22
80-89:	7

CA not listed. *MA* 9 yrs., 3 mos.:

The boys were generally tested within two years of the survey. The presence of a large group with *IQ*'s above 70 at an institution for the feebleminded seems to be largely due to the fact that many boys are emotionally disturbed when the question of their institutionalization comes up and test lower than some weeks later when adapted to institutional life.

*Received in the Editorial Office on June 10, 1946.

[1]Sixteen years was used as *CA* in the computation of the *IQ*'s of the boys above 16.

The unconscious sighting preference of the boys was determined by a method almost identical with the one reported by W. R. Miles (12, 13).

Funnels of thin cardboard were used, approximately conical in shape when opened, identical in size and shape with Miles' *V*-scope. They had to be held in two hands and compressed in order to be opened. The subjects were shown the proper way to hold the funnels and were asked to look at objects held by the experimenter and to name them.

As pointed out by Miles (13), even intellectually superior subjects practically never recognize that they sight with one eye only when looking at a fairly distant object through the funnel. The experimenter can readily determine the sighting eye by observing the subject. Six consecutive trials were used in most cases, more than six in six instances, four in one case.

The handedness of the boys was determined in terms of their answers to the questions, which hand they used in writing, throwing a ball, batting. They were asked to show the hand. In one case the testimony of the athletic director was used. In addition, most of the subjects were asked to write with both hands and to throw a baseball to the experimenter, outdoors or across a large room, first with one hand, then with the other.

RESULTS

The results of the sighting preference tests are presented in Table 1.

TABLE 1

Number of times the subject sighted with Right eye	Left eye	Number of subjects
6	0	31
5	1	3
6 or 5	2	2
4	2	8
5 or 4	3	2
3	3	4
2	4	2
4	9	1
1	5 or 7	2
0	4	1
0	6	4
		Total 97

The frequencies of various combinations of sighting preference and hand preferences in various activities are presented in Table 2. Boys using the same eye each time, with no more than one exception, are listed as right-sighting or left-sighting respectively, the remainder as sighting with either eye impartially. If the boys sighting with the same eye in more than two-

thirds of the trials are included in the right-sighting and left-sighting groups, slightly different totals result.

TABLE 2

Number of boys in various hand-sighting eye combinations
R=right L=left E=either

Writing	Throwing	Batting	R-sighting	L-sighting	E-sighting	Total
R	R	R	27(29)	29(30)	15(12)	71
R	R	None or no record	2	1	1	4
R	R	L	1	1	1	3
R	L	R		2	1	3
L	L	R	1			1
R	L	L	1	5	1	7
L	L	L	2	6		8
		Totals	34(36)	44(45)	19(16)	97
		Percentages:	35.1%(37.1%)	45.4%(46.4%)	19.6%(16.5%)	

Boys were classified as right handers if they wrote, threw, and batted right handed, as probable right handers if they wrote and threw right handed and did not play baseball (only 3 out of 74 right handed throwers who played baseball were left handed batters). The boys using the left hand in throwing and batting were classified as predominantly left handed, the right handed writers among them as retrained left handers. This was done because there was clear evidence of strong social pressure in the direction of right handed writing in the figures. All right handed throwers wrote with the right hand while only 9 out of 19 left hand throwers wrote with the left hand; all but one of the right handed batters were right handed writers, only eight left handed batters out of 18 wrote with the left hand. The boys in whose case there was a discrepancy between the throwing hand and the batting side were classified as mixed handedness cases, mainly because there seemed to be little difference between throwing and batting as indicators of handedness. The percentages of right handers, left handers, and mixed cases thus defined were 77.3 per cent, 15.5 per cent and 7.2 per cent.

The number of boys whose hand preferences and sighting preferences coincided was 35(36.1%) if only the pure left handed were counted, 40(41.2%) if the retrained left handers were included, 42(43.3%) if the impartially sighting mixed handers were included.

Results Compared to Previously Reported Distributions of Handedness and Sighting Preference

These results differ considerably from the results of similar studies conducted by other investigators with normal subjects.

1. As compared to normal groups, our subnormal group contains much fewer right-sighting individuals, more boys sighting with the left eye, several times as many boys sighting impartially. Table 3 presents the percentages of sighting preferences reported by a number of investigators.

TABLE 3

Author	% R sighting	% L sighting	% Impart. sighting	Number and type of subjects
Parson (17)	69.3	29.3	1.4	877 P S children
Miles (12)	66	31.5	2.5	203 Misc., mostly super. adults
Miles (12)	67	30	3	172 P S children
Cuff (3)	62.7	34.7	2.7	75 P S boys
Cuff (3)	62	22.5	15.5	71 P S girls
Quinan (19)	73	23	4	2333 University students (% read off graph)
Hildreth (8)	56.2	36.6	6.8	191 Private School children
Jastak (10)	55.8	36.4	7.8	820 cases, type not stated
Travis (23)	73	22	5	55 normal people
Schonell (20)	63	29	8	75 children
Johnson & House (11)	42.4	54.5	3	33 P S children

The percentage of right sighting in our group is only about half to two-thirds as large as the general run of percentages obtained with normal subjects; 16.5 per cent, our percentage of impartial sighting is several times as large as the normal percentages, only one of them being larger than 10 per cent. The percentage of left sighting boys is larger than was found in any of the normal groups with exception of one very small one. The unusual distribution of sighting preferences in our group cannot be attributed to fluctuations of random sampling; the hypothesis that our subjects and e.g., Jastak's subjects are two random samples of the same homogeneous population is readily disproved, the corresponding chi-square being 15.5125, giving for two degrees of freedom a P less than .01.

In order to study the matter further, the distributions of sighting preferences for boys with IQ's of 70 and above, 60 to 69, and below 60 were compared. No significant differences emerged.

The distribution of sighting preferences in our group of intellectually subnormal boys is rather similar to a number of distributions obtained with subjects selected on a basis of presence of various kinds of abnormal behavior,

such as stuttering, reading difficulties, and reckless driving. Table 4 presents the distributions of sighting preferences of subjects exhibiting various maladjustments.

TABLE 4

Author	% R sighting	% L sighting	% Impart. sighting	Number and type of subjects
Travis (23)	50	45	5	48 students
Bryngelson (2)	32.4	57.3	10.3	700 stutterers
Millisen (14)	50	25	25	23 stutterers
Jasper (9)	54	21	25	stutterers
Spadino (21)	56	37	7	70 stutterers
Johnson and House (11)	57.6	36.4	6	33 children with articulatory disorders
Schonell (20)	51	45	4	73 poor readers, children
Hildreth (8)	54.5	40.9	4.6	22 poor readers, children
Gilkey and Parr (6)	46	50	4	50 children, reversal errors in reading
Wolfe (26)	61	39	0	18 children, reversal errors and retard. reading
Wile (25)	30	62	8	50 problem children, reading disability
Quinan (18)	45.6	45.6	8.5	70 const. psychop., alcohol., drug add., psychotic, feeble-minded
Quinan (19)	ca. 48	ca. 48	7.4	121 reckless drivers in Traffic Court (figures read off graph)

The percentages reported by the various authors differ to a marked extent, which is partly but not wholly due to the small size of a number of the groups of subjects. The reasons for the wide variations are not clear. Nevertheless, the principal characteristics of the distribution of sighting preferences in our group of subnormal boys, a low percentage of right sighting and a high percentage of impartial sighting, have been repeatedly found in other abnormal groups.

2. It is difficult clearly to establish the significance of the distribution of handedness in our subnormal group, in view of the varying definitions of handedness and the frequently incomplete reports of the data in the literature. Nevertheless, the incidence of left-handedness appears to be increased in our subjects, 15 individuals (15.5%) being predominantly left-handed. This percentage agrees closely with 18.2 per cent, H. Gordon's (7) percentage of left-handedness, among the children in the London schools for mental defectives. Most reported percentages of left-handedness in normal populations are considerably lower, generally between 4 and 9 per cent. For example, Gordon (7) found 7.3 per cent left-handed children in London

elementary schools; Quinan (19) 7.3 per cent left-handedness in a group of 2331 college students; Palmer (16) reports 8.3 as the per cent of left-handed throwers among 100,000 people examined in O'Connor's laboratory; Stromberg and Stromberg (22) found 4.4 per cent among 1569 university faculty members; Ojemann (15) obtained 5.2 per cent left-handedness among 518 school children. Assuming that 8.3, the largest one of the above figures represents the true percentage of left-handedness, percentages in random samples of the size of our group, drawn from such a population, should be approximately normally distributed with a standard error of 2.7 The difference between our percentage of predominant left-handedness and 8.3 per cent is 2.67 times this standard error, or highly significant in R. A. Fisher's terminology. It is not altogether clear what the higher percentages of left-handedness occasionally reported in published studies are due to; Downey (5) quotes several such studies in her review.

Seven boys in our group had mixed hand preferences. Seventy-one boys (73.2%) were right-handed on all three of our tests. The percentage of right-handedness in our group was lower than is usually reported in the literature [e.g., Ojemann (15), 92.4%; Hildreth (8), 88.5%; Bryngelson (1), 83%]; even the inclusion of all right-handed throwers in the right-handed group only raises the percentage up to 80.4. The three boys listed as writing and batting right-handed but throwing left-handed could not be included in the right-handed group because two of them had previously written with the left hand, while the third one could write almost equally well with both hands. It is impossible to evaluate the number of boys with mixed handedness in view of the widely varying definitions and estimates of prevalence of ambidexterity in the literature.

3. The number of boys whose hand preferences and sighting preferences coincide is much smaller than is generally reported for normal subjects. Depending on the definition of such "ipsilateral" preferences, our figure was 36.1 per cent to 43.3 per cent. The following corresponding percentages were found in the literature or computed from the published data: 73.5 per cent (Parson, 17); 58.9 per cent (Cuff, 3); 63.4 per cent (Miles, 12); 56.0 per cent (Hildreth, 8); 60.0 per cent (Schonell, 20); 75 per cent (Dart, 14); ca. 73 per cent (Quinan, 19).

On the other hand, similarly low percentages of "ipsilateral" individuals have been repeatedly found in abnormal individuals; e.g., in a group of psychopaths, alcoholics, drug addicts, psychotic feebleminded, in a group of reckless drivers, in a group of stutterers. The reported percentages of con-

cordant lateral preferences for these three groups were 44.2 per cent (Quinan, 18), 45 per cent (Quinan, 19), 19 per cent (Bryngelson, 1)[2] respectively.

4. In order to investigate the above findings more fully, the distributions of handedness were studied within groups established on the basis of sighting preference. Similarly, the distributions of sighting preference within handedness groups were examined. If the primary classification was on the basis of sighting preference, nothing significant emerged. The distribution of handedness, both within the right-sighting and within the left-sighting group are within normal limits. The percentages of right-handers and left-handers in our right-sighting group are similar to those found by Cuff (3) and by Hildreth (8) in normal children; the distribution of handedness in our subjects sighting with the left eye, almost identical with the distribution found by Parson (17).

On the other hand, the distribution of sighting preferences in subjects classified according to handedness are very different from those obtained in normal groups. In our right-handed subjects, the number of left-sighting boys is somewhat larger than usual; the number of impartially sighting boys, very much larger. The mixed handedness group was too small to give significant results the divergences from normal subjects appearing to be in the same direction as in the right-handed group. In the left-handed group, the number of left-sighting individuals is relatively very large, the number of right-sighting boys small as compared to published figures pertaining to normal groups. The figures are as follows:

Among our 75 right-handed subjects, 38.7 per cent were right-sighting, 40 per cent were left-sighting, 21 per cent impartially sighting. The corresponding percentages for normal subjects found in the literature ranged from 58 per cent to 75 per cent for right-sighting, from 23 per cent to 35 per cent for left-sighting, from 1.5 per cent to 9 per cent for impartially sighting.

Two of the seven subjects in our mixed handedness group sighted with the right eye, three with the left eye, two impartially. Jasper (9) had found in a group of 39 ambidextrous subjects 22 right-sighting, 10 left-sighting, 7 impartially sighting individuals.

Most investigators of sighting preferences found that approximately equal numbers of left-handers sight with the right and with the left eye. Parson's data appear to be the only exception. He found very few right-sighting left-handers, possibly because he may have failed to look for retrained left-handers among his right-sighting subjects. Seven sets of approximately equal numbers of right-sighting and left-sighting left-handers were found in the litera-

[2]Concordant hand, sighting, and foot preferences in Bryngelson's study.

ture, the total numbers in the six studies being 134 right-sighting and 139 left-sighting left-handers. In an additional source (12), it was reported that about equal numbers were found among 50 left-handers. In our group of 15 left-handers, there were three right-sighting boys, eleven left-sighting, one impartially sighting.

The probability of obtaining a sample divided in a 3 to 11 ratio in the expected direction, drawn at random from an evenly divided population is .029. This is not impossible, but not very probable. The divergence between our distribution and that obtained in normal subjects is probably not due to random sampling.

Summary and Conclusions

The following somewhat interpretative summary appears to fit the results.

1. In all handedness groups among our mentally subnormal subjects the number of right-sighting boys is considerably smaller than in groups of normal subjects. In the right-handed group the relative number of impartially sighting subjects is increased. In the left-handers, the number of left-sighting subjects is increased..

2. The results for the group as a whole were similar to those obtained in the right-handed group. This could hardly have been otherwise, since about 75 per cent of our group were right-handers.

3. Relatively few boys (as compared to normals) were found to have concordant hand and sighting preferences. This was entirely due to the relatively small number of right-sighting right-handers. Ipsilateral preferences were actually unusually frequent among left-handers.

4. In the group as a whole, the number of left-handers was found to be rather large, not clearly so in the sub-groups classified on the basis of sighting preferences.

No explanation of the findings can be offered with certainty. In 1920 H. Gordon (7), who found an excessive number of left-handers among intellectually subnormal children, suggested that this excess may be due to instances of disease of the central nervous system reversing the native handedness and leading to intellectual subnormality in many cases. This hypothesis is plausible and may be equally applicable to our data, which are characterized mainly by increases in numbers of left and impartial sighting preferences. Data pertaining to the distributions of handedness and sighting preferences in the families of intellectually subnormal children may shed further light on the validity of Gordon's hypothesis and on the related topic of the rôle of heredity in mental defect; e.g., if it should be found that the distribution

of laterality patterns in mental defectives differs markedly from that in their parents, Gordon's interpretation would be confirmed and the development of new techniques for the study of non-hereditary cases of mental defect may be aided.

References

1. Bryngelson, B. A study of laterality of stutterers and normals. *J. Soc. Psychol.*, 1940, **11**, 151-155.
2. ———. Personal communication to E. L. Travis and W. Johnson. Quoted in (24).
3. Cuff, N. B. The interpretation of handedness. *J. Exper. Psychol.*, 1928, **11**, 27-39.
4. Dart, C. Eye, hand, and foot preferences of mentally subnormal subjects compared with individuals of normal and superior intelligence. *J. Juv. Res.*, 1938, **22**, 119-122.
5. Downey, J. E. Laterality of function. *Psych. Bull.*, 1933, **30**, 109-142.
6. Gilkey, B. G., & Parr, F. W. An analysis of the reversal tendency of fifty selected elementary school pupils. *J. Educ. Psychol.*, 1944, **35**, 284-292.
7. Gordon, H. Lefthandedness and mirror writing especially among defective children. *Brain*, 1920, **43**, 313-368.
8. Hildreth, G. A school survey of eye-hand dominance. *J. Appl. Psychol.*, 1945, **29**, 83-88.
9. Jasper, H. H. A laboratory study of diagnostic indices of bilateral neuro-muscular organization of stutterers and normal speakers. *Psychol. Monog.*, 1932, **43**, 72-174 (quoted in (24)).
10. Jastak, J. The ambigraph laterality test. *J. Appl. Psychol.*, 1939, **23**, 473-487.
11. Johnson, W., & House, E. Certain laterality characteristics of children with articulatory disorders. *Elem. Sch. J.*, 1937, **38**, 52-58.
12. Miles, W. R. Ocular dominance demonstrated by unconscious sighting. *J. Exper. Psychol.*, 1929, **12**, 113-126.
13. ———. Ocular dominance in human adults. *J. Gen. Psychol.*, 1930, **3**, 412-430.
14. Millisen, R. A comparative study of stutterers, former stutterers and normal speakers whose handedness has been changed. *U. of Iowa thesis*, 1933, quoted in (24).
15. Ojemann, R. H. Studies in handedness: I. Testing unimanual handedness. *J. Ed. Psychol.*, 1930, **21**, 597-611.
16. Palmer, G. One to three you are left-handed. *Sat. Eve. Post*, 1943, **215**, p. 11ff.
17. Parson, B. S. Left Handedness. New York: Macmillan, 1924.
18. Quinan, C. The principal sinistral types. *Arch. Neurol. & Psychiat.*, 1930, **24**, 35-47.
19. ———. The handedness and eyedness of speeders and of reckless drivers. *Arch. Neur. & Psychiat.*, 1931, **26**, 829-837.
20. Schonell, F. J. The relation of reading disability to handedness and certain ocular factors: II. *Brit. J. Ed. Psych.*, 1941, **11**, 20-27.
21. Spadino, E. J. Writing and laterality characteristics of stuttering children. *T. C. Contrib. Educ.*, 1941, No. 837.
22. Stromberg, E. T., & Stromberg, E. L. Left handedness as a factor influencing academic achievement. *J. Soc. Psychol.*, 1938, **9**, 335-341.

23. TRAVIS, L. E. A comparative study of the performance of stutterers and of normal speakers in mirror tracing. *Psych. Monog.*, 1928, **39**, 45-50. Quoted in (24).

24. TRAVIS, L. E., & JOHNSON, W. Stuttering and the concept of handedness. *Psychol. Rev.*, 1934, **41**, 534-561.

25. WILE, I. S. Eye dominance: Its nature and treatment. *Arch. Ophthalmol.*, 1942, **28**, 780-790.

26. WOLFE, L. S. Differential factors in specific reading disability: I. Laterality of function. *J. Genet. Psych.*, 1941, **58**, 45-56.

Department of Psychology
College of the City of New York
School of Business and Civic Administration
17 Lexington Avenue
New York City

The Journal of Genetic Psychology, 1947, 71, 85-136.

THE ORIGIN AND EVOLUTION OF BISEXUAL DIFFERENTIATION*

Wading River, New York

EDWARD J. KEMPF, M.D.

Understanding the thermo-bidynamics of the origin and evolution of bisexual differentiation in Protozoa and in Metazoa for the cytoplasm, chromosomes, gonads, gonoducts, and somatic organs is basic for understanding the bisexual differentiation in the ontogeny of the organism and the personality of man. Two great problems have perplexed biology since the development of evidence for the genetic theory of hereditary transmission. How is the timing and placing of the differentiation of cells in embryonic development hence bisexual differentiation determined, if all cells in the organism inherit like chromosomes? How can acquired characters be inherited?

The following presentation of experimental evidence demonstrates that neither the evolution of species nor the development of the individual is solely the result of chance chromosomal accumulative organization of chance genic mutations under the directional limitations of the natural selection of more of the fittest phenotypes, hence genotypes, for survival and reproduction. It demonstrates that holistic autogenous determination in counter-balancing interaction with internal and external imbalancing conditions is the most fundamental and characteristic process of the multiple energies of life. It further shows that self-determination and bisexual differentiation are inseparable in the development of the individual and in the evolution of species and constitute basic factors in the production of health and disease. It also shows that ontogeny recapitulates phylogeny and phylogeny follows ontogeny through environmental *quantification* in differentiating ratios of the chromosomally produced *qualification* of the cytoplasmic constitution of cells. Several innovations are introduced in the synthesis of the experimental analytic and taxonomic evidence on the differentiating and developing processes of life.

The bisexual constitution exists potentially in equal M/F ratios in conjugating reproductive primitive protoplasm. It definitely exists in equipotential M/F ratios in the chromosomes and zygotes of bifertile herma-

*Received in the Editorial Office on June 18, 1946.

phroditic unicellular and multicellular animals and plants, but M/f and F/m cytoplasmic[1] differences exist in their gonads, if all cells of the organism normally inherit like chromosomal complements except in the meiosis of gametes, as cytology now holds (Cowdry, 7; Sharp, 36). The bisexual constitution exists in more or less unequal M/f and F/m ratios in the chromosomes and cytoplasm of zygotes of unifertile, heterosexual animals and plants, and in their gonads, germ cells, gametes and other cells of the organism.

In functional hermaphrodism quantitative bisexual differences exist in the cytoplasm only. They develop in the gonadal cells located in special positions in the organism and exposed to special organismic and environmental differences in physico-chemical activation, respiration, nutrition, and elimination. *In heterosexualism, quantitative bisexual differences exist in the cytoplasm and in the chromosomes.* The cytoplasm is generally able under sufficient androgenic or estrogenic nutrition, except in some instances late in isothermal evolution (in the skin of some birds), to undergo reversal in its quantitative ratios against the effects of chromosomal differentiation without changing the chromosomes. Bisexual differences in chromosomes have long been known and the $AAXX$ and $AAXY$ symbols for autosomes and sex chromosomes are used by geneticists, but no bisexual symbols for the cytoplasm have as yet been adopted, although evidence has been found (Goldschmidt, 13; Sharp, 36) for the hereditary transmission of bisexual cytoplasmic factors and their quantitative differences in gonads, germ cells, and gametes are well known.

Taxonomic evidence indicates beyond question that hetrosexualism evolved from hermaphrodism. Bisexual differentiation must have originated in the ratio of bidynamic aggregates (anabolic/catabolic) of the *cytoplasm* of germ cells or zygotes, followed later by progressive *chromosomal* differentiations. Hence it is necessary to study the evolution of bisexual differentiation at the level of the holistic A/C bidynamic ratio, which includes the M/F ratio of the cytoplasm, and the $AAXX$ or $AAXY$ genic ratio in the chromosomes.

Studies of bisexuality have been centered upon the hereditary transmission of characters through genes and the chromosomal genic organization, and their effects on gonadal and somatic cytoplasmic differentiations and germina-

[1]Cytoplasm is used here to include the protoplasm within the nuclear membrane (nucleoplasm), but not the chromosomes, and the protoplasm within the outer cell membrane, to cover the bidynamic interactions of cell adaptation. Since the chromosomal-genic organization is the principle means of qualitative cytoplasmic determination and the nuclear membrane is at times in solution this differentiation is consistent with the functions of cells.

tion, the effects of gonadal and other endocrine secretions and other chemical substances, and humidity, heat, light, and stimulation, on growth and differentiation. Knowledge of these processes has grown extensive and practical, but it is inadequate for solving the general problem of the origin and evolution of bisexual and somatic differentiation until correlated with the differentiating effects of heat and other environmental activations on the *bidynamic ratio of life.* The energies of life are not differentiated in biology and biochemistry into so-called vegetative, sexual, and psychic, as some psychologists assume, but are naturally differentiated as *anabolic and catabolic physico-chemical energies* obeying the laws of thermodynamics.

The following presentation will show that the *autogenous* determinant of the origin and evolution of bisexual and somatic differentiation is the *bidynamic ratio of the whole cell or organisms of cells,* working to maintain internal with external equilibration for the extension of viability and reproductivity. It works against the imbalances of self-consuming catabolism and variable exogenous conditions, including *heat, light, humidity, respiration, nutrition,* and *elimination,* with heat the one universal and basic factor, hence by far the most important.

Heat, as unorganized intramolecular and intermolecular motion, is indispensable for all chemical motion, including life. It is produced by chemical as well as physical motion and is transformable into the organizations of either. All forms of anabolic organization of cytoplasm or its catabolic decomposition upon physical or chemical shocking stimulation are thermodynamic. Heat regulates the equilibratory level of interactions of gases, liquids, and solids, of solvents and solutes. The oxidation-reduction processes of living and lifeless chemistry are enormously accelerated by heat, increasing the collision frequency and efficiency of ions. (The chemical reaction rate doubles for each 10° C.) The chief source of heat for life is solar. Its direct and indirect solar radiations are universal and it varies in intensity in annual and diurnal cycles and within cycles through meteorological and other intercepting and transmissive conditions. It ranges from an average mean that supports life to extremes that are first destructive to reproductivity and then to viability. The continuity and evolution of life is necessarily dependent upon making equilibrating chemical and physical adaptations within mean, limiting ranges of heat peculiar to the special chemical constitution of the cell, hence it must be active in the origin and evolution of bisexual differentiation as well as other forms of metabolic differentiation and organismic growth. Other variable environmental determinants of the evolution of reproductivity and possibly of bisexual differentiation are oxygen and other

nutritional substances, light and humidity, but they are secondary to the effects of heat as will be shown.

The Bidynamic Ratio of Life

A modern concept of the living cell (Baitsell, 2) sees it as a highly complex, holistically organized, protoplasmic unity of many specialized molecular protein subunits, many of which are related to the viruses and none of which are essentially different, except in organization, from lesser molecules found outside of life. These parts in the organized whole are not entirely static or fixed in constitution or position but are more or less in structuralizing and destructuralizing motion in an organized system of moving parts. Miscroscopic views of the cell do not differentiate anabolic from catabolic structures or processes, but it is erroneous to assume that they are all anabolic or static.

A bidynamic, anabolic-catabolic concept of life is now generally held for the biochemistry of the cell, but the manner in which it works is variously conceived. Many cytologists have thought, from the study of stained dead cells, that anabolism is a positive system of processes and catabolism is a negative after-effect or form of intra- and intermolecular collapse, releasing energy like a falling body; others have compared the combustion of carbohydrates within the cell structure to gas engine combustion. The present status of evidence on cell metabolism (Heilbrunn, 15) shows that such concepts are utterly inadequate.

The living cell's bidynamics includes a counterbalancing anabolic system of autogenously$\times$exogenously directed, graded, slowly oxidizing, energy assimilating and upbuilding, electro-chemical processes, and a catabolic system of autogenously$\times$exogenously directed and graded, rapidly moving and oxidizing, energy breaking down, releasing and projecting, electro-chemical processes. The two systems work in a reciprocally organized, interweaving flow of reversible and irreversible substances around qualitatively, quantitatively, and positionally allied and antagonistic enzymes. The energic reserves of specially prepared fat, carbohydrate, protein, and metal and nonmetal elements stored in the cell are not "burned as fuels," but, as indicated by the best evidence on radioactive isotopes in metabolism (Schoenheimer, 35), they become anabolically worked over into the living protein structures of the cell before they are catabolically broken down for energy release in work and heat. The assimilation and building of energy is the opposite of breaking down and releasing energy. Cells that are strong anabolically are often weak catabolically or vice versa. The imbalance either way is detrimental to life unless counterbalanced by exchanges with other cells.

The continuity of an orderly, graded, breaking down catabolism is indispensable for life, as the means of supplying energy for the completion and differentiation of anabolism and keeping it in a state of ready reactivity or structuralizing movement of kinetic potentials, for preventing its freezing, stasis, or collapse. Anabolic properties that cannot be catabolized may become deleterious to life. Catabolism is quantitatively accelerated or decelerated in its different qualities by increases or decreases in special activating or excitatory environmental energies (heat, light, water, pressures and vibrations, oxidations and eliminations of wastes and physical and chemical shocking contacts of different kinds), producing thereby adaptable quantitative rates of consumption of special qualitative, anabolic reserves. This results in superficial and deep intracellular variations in anabolic/catabolic ratios with special reductions in viability and reproductivity. Reproduction of the whole leading to cell division reduces all anabolic resources and catabolic capacities, with stress of the weakest quantities first.

Whenever the living cell is anabolically deficient in any way it is chemically driven to work repetitiously to acquire, assimilate, and anabolize adequate quantities of right qualities of nutritional substances for rebuilding itself wherein it is weak, in order to restore its internal with external equilibration and the counterbalancing, bidynamic organization of its integrity as a whole. Such selective deficiencies or needs and cravings are counterbalanced in a number of ways: (*a*) through ingesting other cells; (*b*) through graded, repeated exchanges between living cells of fitting quantities and qualities of hormones and other nutritional substances; or (*c*) through conjugation or fusion between two cells, one of which is strong in quantities of anabolic or catabolic qualities wherein the other is weak, that is, has a *complementary bidynamic ratio.*

Animal and plant cells, whatever their species, are continuously, catabolically, more or less rapidly self-consuming, and must acquire and build into their living mechanisms quantitative ratios of special anabolic properties to counterbalance the ratios of their special forms of catabolism. The laws of motion and conservation of energy apply to all forms of life, as cell units or multicellular unities; hence the work, differentiation, growth, and evolution of life is based on its bidynamic ratio. The aggregate of anabolic processes in proportion to the aggregate of catabolic processes of the whole protozoan or metazoan cell having adequate organization of qualities, is an index of its need to work for viability and reproductivity and its dependence on other cells for support wherein it is weak. The range of anabolic/catabolic ratios adequate for reproductivity is evidently far more

narrowly limited and specialized than the range for viability, hence is more selective in the evolution of life.

Bisexual Differentiation in Unicellular Mating Selection for Holistic Reequilibration

Bisexual differentiation in bidynamically imbalanced Protozoa is demonstrated in their *positive* or *acquisitive* and *negative* or *avoidant* mating selections. Positive selections generally lead to the self-preservation of holistic physico-chemical integrity, through quantitative reequilibration of the substances and processes essential for viability and reproductivity, when they do not include lethal genic combinations.

Two sexes or mating types that conjugate have been demonstrated in each of several different stocks of *Paramecium aurelia* by Sonneborn (39, 40) and Kimball (27). The stocks do not crossbreed and are possibly varieties or species or have long lasting cytoplasmic modifications that are antagonistic to cross breeding although not evident in morphological differences. Opposite mating types conjugate under predisposing heat and darkness and other physical conditions, but differ markedly in their potentialities. Conjugations repeat most frequently after a variable number of divisions following a conjugation and a not too complete or too deficient nutritional status. More of Variety I conjugate at 9° C. to 30° C., at any time. More of Variety II conjugate at 20° C. from 1 A.M. to 5 A.M., and more of Variety III conjugate at 24° C. between 4 A.M. and 11 A.M. Five days of continuous darkness seems to have an accumulative conjugating determination for it occurs freely for some time in daylight. Five days of continuous light has an accumulative anticonjugating effect for it inhibits conjugation at night. Hence darkness disposes to conjugation and light suppresses it, but other chemical timing reactions in relation to the diurnal cycle are indicated.

Two kinds of nuclear reorganization processes have been found in *P. aurelia*. One occurs at conjugation and is biparental in origin through exchanges of the migratory halves of the nucleus, and the other is uniparental and occurs irregularly with "endomixis" of chromosomal parts.

The inheritance of mating or sex types follows different rules and shows different features in different Protozoa. *After conjugation* the progeny of some individuals are all of one mating type and the progeny of other individuals are all of the other mating type and the progeny of still others are of both types. Where both types are produced the descendants of the series of vegetative reproductions are generally all of the same type until endomixis

occurs. *After endomixis* some individuals have progeny of one mating type and others have progeny of the other type and still others have progeny of both types. The determination of the sex or mating type, Sonneborn concludes, is made by some process that is common to both biparental and uniparental reorganization, which is probably in relation to the macronucleus, as reorganized with biparental conjugation and uniparental endomixis. It is subject to genic determination under Mendelian laws and also to environmental determination, particularly heat.

The degree of heat or temperature at the time of nuclear reorganization and formation of the macronucleus (biparental or uniparental), and not after the first division, has been found to have highly significant effects for sex determination and its inheritance. After the first division the sex type seems to be formed for the succeeding reproductions until the next nuclear reorganization. The degree of heat seems to influence the genotype of the macronucleus in one sex direction or the other and it then generally reproduces a phenotype consistently. This particular form of inheritance of acquired characters seems to be limited to Protozoa having macronuclei. At low temperatures, 10° to 19° C., in uniparental reorganization the ratio of sex types is about equal, whereas at high temperatures, 20° to 30° C., a ratio of 2 to 1 appears. The sex ratios are more affected by high temperatures at conjugation or endomixis, with possibly the greatest differences when high temperatures exist at both times. Mating types appear, disappear, and reappear at nuclear reorganizations under thermal and other environmental influences apparently under *chance orders.* The genotype of a "caryonide" (descendants inheriting the same macronucleus) generally remains the same in sex type until nuclear reorganization but the phenotype or cytoplasm may continue to reproduce in the opposite sex with similar lags in changes of body size and other characteristics. Such members of the same caryonide will conjugate for several generations. Marked sex consistencies are found in some caryonides and reversible irregularities are found in others. Conjugation nevertheless occurs only between two individuals of opposite mating types whether genically or environmentally produced.

Jennings (20, 21) found in *Paramecium bursaria* a multiplicity of mating types in three groups. The same type does not conjugate with its kind or across the group barrier. The preceding evidence discredits the previously accepted view that Protozoa generally mate indiscriminately. Sonneborn concludes that in free-living ciliate Infusoria two general relations are found: (*a*) Extreme diversity exists in different species and even races within the species. (*b*) In any species or race a clearly demonstrable system of sex

diversity and determination is found that is comparable to the sex differentiations of higher organisms.

It is well established that some environmental conditions—imbalancing extremes of heat or other forms of chemical activation—produce definite cytoplasmic and possibly nuclear changes in the organism. Such "acquired characters" are hereditarily transmitted for several to many generations (Jollos, 24). The parts played by such "long lasting modifications" in evolution can only be worked out in correlation with the hereditary transmission of genic characters. In about three per cent of Kimball's (27) stock of *Paramecium aurelia*, Type I produced Type II and Type II produced Type I in the absence of nuclear reorganizations, indicating cytoplasmic changes from environmental influences.

In *Paramecium multimicronucleatum* Giese (12) found mating types, but in most of the stocks conjugation occurs between progeny of the same individual. Such environmental factors as heat, salts, pH, metabolites, and population density modify the onset, intensity, and duration of conjugation. It is retarded by extreme temperatures of 8.4° and 30° C. and accelerated by temperatures from 15° to 26° C. with the highest rate around 26°. Distilled water and too high salt concentrations inhibit conjugation. Overcrowding followed by reduction of food more than accumulations of excreta or chances of meeting accelerates conjugation.

Protozoan reproduction may repeat for a varied number of generations and has been artificially continued for thousands of generations through providing adequate nutritional substances and eliminating excreta, but generally the rate slows down, even under favorable, natural food and other environmental conditions, until it finally ceases. Apparently some minute, delicate, essential physico-chemical components (anabolic and/or catabolic) become reduced and some part of the intracellular mechanism grows weak and deficient whereby the cell decreases in viability and reproductivity. Eventually the organism disintegrates (dies) if it does not unite with a properly constituted mate. In flagellates two individuals form one complete union, leading to reproduction. In the ciliates union is incomplete, being limited to exchanges of one half of each nucleus (Kudo, 28).

Very well nourished organisms do not conjugate, but if run down paramecia are placed in the same drop of water they show either acquisitive (attractive) or avoidant (repellant) reactions to each other which are unquestionably expressions of special forms of chemical imbalance and motivation. If acquisitive they unite side to side and their nuclei divide. Through openings that form between the adjacent walls each cell exchanges one

meiotic half of its nucleus and retains its original extranuclear cytoplasm. The two formerly depleted cells then undergo nuclear reorganization and become rejuvenated, probably through getting a more balanced ratio of nuclear (chromosomal) chemical properties which revives cytoplasmic activities, and then causes avoidant separation. Such new organisms vary in the degree of rejuvenescence of powers to start new sequences of divisions under fitting nutritional and other environmental support. Some die without reproduction, indicating that some constitutional energic combinations retain too unbalanced anabolic/catabolic ratios, while other pairings have more of the right constituents for rebuilding vigorous, well balanced, reproductive physico-chemical mechanisms. Different strains of the same species of Paramecium and different individuals in a strain vary in capacity for living, growth, and reproduction under identical conditions.

The run-down protozoan cells, after a sequence of divisions, become *end-products* of such metabolic activities, equivalent to the ovum and spermatozoon *end-products* of metazoan germ cell meiosis. In both instances they are internally, incompletely balanced or lacking in adequate quantities of anabolic and/or catabolic substances to carry on the work of living, and have chemically positive, selective, acquisitive, mating craving needs for complementary opposite types, and negative, avoidant compulsions for like or misfit types. Their positive reactions probably work as special, physico-chemical, electrically sensitive motions to acquire reequilibration and reconstitution of internal imbalances, through meiotic nuclear exchanges in isogamous Paramecia, or complete union between opposite types of meiotic cells having complementary ratios of bidynamic properties in anisogamous Sporozoa and Metazoa.

The positive mating reactions between two individuals of complementary opposite ratios are mechanistically like the special appetitic cravings for acquiring special qualities and quantities of foods, produced by anabolic deficiencies. The negative, avoidant reactions, like anabolic satieties producing compulsions to avoid certain foods, work between individuals having like constitutional ratios or quantities of qualities. Such selective mating behavior is certainly best explained by the hypothesis that sex differences in Protozoa, as in the gametes of Metazoa, are based on bilaterally opposite quantities of like chemical qualities rather than unilateral differences in qualities as was once thought. *Opposite complementary ratios in the quantities of like anabolic and catabolic qualities in one-celled animals determine selection in conjugation or fusion and have the essential conditions of sex differences.*

Viability and *reproductivity* are normally renewed by conjugations or fusions that acquire special nuclear and cytoplasmic substances when the nutritional state cannot be otherwise adequately equilibrated. The chemical processes of assimilation of special nutritional substances are evidently basically related to conjugation or fusion as physico-chemical processes of reconstruction or growth for self-preservation of holistic integrity through equilibratory processes.

We may conlude that the anabolic processes of *growth* have specialized into two ways: (*a*) those which build up and complete, or rebuild worn out parts of the cell; and (*b*) those which duplicate all parts of the whole and end in cell reproduction.

Mating behavior is produced by a deficiency of anabolism and/or catabolism in a cell exciting chemical affinities, sensitivities, and motivities (cravings) for union with another cell having complementary opposite ratios of counterbalancing properties. These differences are properly called sex differences when they lead to conjugation or fusion to increase the powers of reproduction. Within the limited field of selective mating is a narrow range of rejuvenescent viability including a more narrow range of reproductivity.

Reproduction seems to be based on the duplication of all chromosomal and cytoplasmic properties. The catabolic compulsion (in bacteria and protozoan and metazoan cells) *to eliminate imbalancing waste products and nutritional excesses seems related to the catabolic compulsion to divide and force off holistic duplications which develop upon excessive accumulations of all anabolic substances, not unlike cleavage following the growth of crystals.* The compulsion to avoid union with cells of like bidynamic ratios seems also to be related to the electro-chemical processes of division.

Reproductive functioning evidently includes mating for anabolic-catabolic reequilibration through nuclear and then cytoplasmic reorganization followed by fitting nutritional intake and division. *Reproductive functioning is one and indivisible in life with self-preservative functioning and the two cannot be separated in their basis for working out a system of physiopsychology.* Every cell and every tissue and organ and the organism as a whole and every act is chromosomally and gonadally determined for its ratios of bisexuality.

Reproductive union is generally limited to two cells but is closely related to and often dependent upon other kinds of intercellular contacts, in which chemical substances are probably exchanged. Some Protozoa form temporary colonial masses or gonads with close physical contact seemingly for nursing the germ cells and their gametes, remarkably like the interstitial nursing

cells of ovocytes and spermatocytes in metazoan gonads. The characteristic clumping of paramecia predisposes to mating and suggests a kind of preparatory gonadal effect. This suggests that *metazoan organisms evolved from permanent metazoan gonads which evolved from temporary protozoan gonads.* Gonadal and genital evolution led to organismic evolution, and autogenous reproductive selection is as important as natural or exogenous selection in evolution.

Comparative Bisexual Differentiation in Protozoan and Metazoan Gametes

In the sexual reproductions of some Protozoa the pairs seem to be morphologically alike (isogamous), while in others they are markedly different (anisogamous). In certain Foraminifera, Volvocidae, and Radiolaria anisogamy is widely distributed and the differences between their microgametes and macrogametes are comparable to the differences between spermatozoa and ova of Metazoa (Kudo, 28). Protozoan microgametes are numerous, flagellated, and highly motile, whereas the macrogametes are few, unflagellated, and immotile. Evidence of reduction meiosis leading to conjugation or fusion has been found in a number of species (Kudo, 28). Male metazoan gametes tend universally to be smaller than female gametes. They are generally elongated, highly motile, flagellated, mechanistically complex, swimming cells adapted for transporting chromosomes and finding and penetrating ova of their species. They are strongly catabolic and weakly anabolic and carry very little nutritional reserve (Popa, 33). The female gametes are generally spherical, immotile and much larger than spermatozoa, varying from invisible size to the enormous eggs of birds and reptiles. Such ova have large anabolic capacities and nutritional reserves to protect the growth of the embryo, and are generally too weakly catabolic for reproduction without fertilization or some other external source of catabolic excitation. In each species the ovum is covered by a specialized, ectoplasmic membrane that is highly resistant to spermatozoa of all species except its own type, and immediate chemical changes upon penetration by the first spermatozoon produce a resistant ectoplasmic protection against others. The sperm and ova of the different species of Metazoa, including man, show complementary morphological and chemical differences of a decisive nature which no doubt evolved with gonadal, genital, and somatic differences and generally prevent cross breeding, particularly in externally fertilizing species.

The processes of impregnation and fertilization of the metazoan ovum by a spermatozoon are remarkably like the fusion of gametes of a number of

Protozoa (Kudo, 28). In fertilization the external identity of the ovum is longer retained and can be observed after the entrance of a spermatozoon. In fusion the external identity of both organisms is quickly lost in the new formation. In the conjugation of some species of Paramecium where only halves of the nuclei are exchanged, the identity of the cytoplasm is retained and can be followed through a number of conjugations (Jennings, 22, 23). The internal identities of the structures of both ovum and spermatozoon are lost in the processes of amphimixis. Evidently there is a phylogenetic repetition in these reproductive processes; fertilization resulting in completion and rejuvenation of the end cells of division, sperm and ova, through forming the zygote, like conjugation or fusion of two incomplete protozoan cells, also the end-products of division, producing a new, complete reproductive cell, which in protozoology is now regarded as a zygote.

The evidence on bisexual differentiation in Protozoa indicates a number of steps in evolution. Jennings (20) compares the haploid *migratory* pronucleus of diploid Paramecia to the haploid nucleus of sperm and the *stationary* haploid pronucleus to the haploid nucleus of ova. Thus Paramecia are hermaphroditic and each of the two exconjugants produces its own line of descendants. In the Vorticellidae morphological or, rather, cytoplasmic differentiations are more highly developed and one is relatively actively *M/f* and the other inactively *F/m*.

The retention of processes of protozoan conjugation in the evolution of metazoan fertilization is further shown by the conjugating behavior of some cells in the blood stream and in the gonads of higher animals. When metazoan cells unite it is probably a rejuvenating process as in run down protozoan cells. Experimental evidence shows that ova and spermatozoa of some Metazoa are both independently capable of mitosis without fertilization under the unusual conditions of artificially supplying the catabolic or anabolic factors in which they are weak. If the ovum of the sea urchin, which is normally nonparthenogenic, is supplied with extracts from spermatozoa it becomes fertilized and reproduces. If the spermatozoon is supplied with the cytoplasm of the denucleated egg it will produce a larval form (cited by Howell, 18). The bisexual differentiation of gametes in naturally nonparthenogenic mammals is by no means complete. Pincus (31) stimulated the ovum of a rabbit without fertilization and produced a mitotic egg which, upon being transplanted to the uterus, developed a fetus which grew into a female capable of reproducing. Later he found that cold shocks applied to the flanks of the rabbit at the time of ovulation were sufficient to initiate mitosis and the development of the embryo.

Parthenogenic evidence has demonstrated that in Metazoa union of haploid gametes is not universally necessary to continue the reproductivity of germ cells. Tissue cultures and tumor growths of somatic cells have shown a similar power of continuous reproductivity without intermediary stages of fusion. This indicates that the difference in germ cell plasm and somatic cell plasm, if their chromosomes are equal, is more one of cytoplasmic anabolic/catabolic ratios derived from electro-chemical position effects and their selective excitatory-inhibitory, nutritional, respiratory and eliminative rates than some more abruptly decisive, unknown factor that is transmitted in one direction and not in another.

Thermo-Bidynamic Differentiation in Metazoa

Evidence of the effects of different intensities of heat and other activating factors on the holistic bidynamic ratio in the direction of cytoplasmic bisexual differentiation in protozoan organisms has been cited. The same factors give origin to the bisexual and somatic cytoplasmic differentiations of multicellular poikilothermic and isothermic organisms as the following evidence shows.

Experimental back tracings of the degrees of differentiation and development of cytoplasmic qualities, quantities, and positions in the cells of the early embryo, to the gastrula, morula, zygote, and ovum, have been reported by Dürken (9) and Wilson (46) and others, for a number of invertebrates and vertebrates. In many anamniotes (ascidians, nematodes, mollusks, annelids, and ctenophores) the eggs give definite evidence of a "mosaic" *determinative differentiation* in the qualities, quantities, and positions of the cytoplasm. Less determinative and differentiated cytoplasmic conditions are found in the eggs of insects. In amphibians, teleosteans, nemertians, Amphioxus, and mammals still less determinative to wholly indeterminative "regulative" differentiations are found in the eggs. Intermediate differentiations in quantitative ratios of special cytoplasmic properties begin to develop immediately in amphibians upon insemination, and become determinative factors in the first cleavage. In the wholly indeterminative types, cytoplasmic differentiations appear in the blastomeres of the morula and blastula and become more decisive and limited in potential adaptabilities with each reproduction as embryonic development proceeds. Dürken concludes that "the fundamental processes of development must be taken to be essentially the same for all groups of animals; it is the outward form only that can vary according to the initial constitution of the germ" (zygote). Experimental regenerations after eliminations and transplantations show that as cells increase in differentiation they decrease in variability but retain more regenerative

potencies than appears in the morphological organizations; that is, they may form other tissues (tumors, sports) than normal for the chromosomal determination.

The zygote is both cell and organism. With the development of the embryo the cytoplasmic constitution of cells progressively differentiates from general complexity to relative specific simplicity, whereas the organism differentiates from simplicity to complexity in morphological and functional organization.

In all blastula formations the basal cells, less exposed to excitation and oxidation, develop heavier cytoplasmic granules, grow larger and reproduce more slowly than the more exposed top cells. In gastrula formation more of the more active cytoplasm is transmitted to ectodermal cells and more of the less active cytoplasm is transmitted to the entodermal cells, with a median distribution to the mesodermal cells.

The triploblastic growth and differentiation of the gastrula is basic for embryonic differentiation in all animals above Coelenterata. The germ layers are interdependently interactive and removal of part of one inhibits or distorts the growth of the others.

The outer surface cells of the gastrula formation, more exposed to an environment of more differentiated and variable light, heat, and physical and chemical contacts, differentiate the ectodermal layer, from which differentiate the more highly resistant and reproductive cutaneous system and the less reproductive but more highly sensitive, conductive and energy augmenting, coördinating and directive nervous system and externally-internally adaptive pituitary glands regulating, through the secretion of tropic hormones, different tissue growths in relation to variations in the basic climatic factors, heat, humidity, and light.

The inner surface cells, exposed to greater quantities of food and its wastes, oxygen intake and carbon dioxide elimination, and less of other stimuli, differentiate the entodermal layer and its descendent external secretory cells and liver and endocrines for energy assimilation and the cells for external respiratory exchange.

The cells within the organism, having an entirely intercellular, interactive environment dependent on the outer cells for sensory guidance, nutrition, and respiration, differentiate the mesodermal layer and its descendent interrelating cells of the blood, the energy projicient, contractile cells of vascular, visceral, and somatic muscle, the elastic connective tissue and the skeletal system of more or less rigid, articulated levers, the sex differentiating gonads and gonoducts, the thermogenic adrenal cortex and the metabolic waste

eliminative nephritic system. The mesodermal system specializes in the circulation and projection of energy under the internal and external direction of the ectodermal nervous system after it has been assimilated and prepared by the entodermal system.

From the basic, graded cytoplasmic differentiations of the three blastodermal layers, the cells of special organs and tissues differentiate in orderly progressions, although at different rates, of more quantities of special cytoplasmic qualities, towards elimination of little used qualities. Deficiencies are supplied by other cells, leading eventually to irreversible preponderance of one or two most used qualities.

The differentiation, rate, and duration of growth of primordial tissues, organs, and systems of organs, and the organism as a whole, is at any time a complexly patterned morphological holistic unity, of many physically and chemically interactive cell units, each having a special position and a differentiated and interdependent bidynamic quantitative ratio of basically like cytoplasmic properties nourished by the same blood. Each cytoplasmic differentiation needs special ratios of special substances (hormones, enzymes, minerals, proteins, fats, carbohydrates, gases) for support. Skin, bone, gland, gonadal cortex, and ova are more strongly anabolic than catabolic, and muscle and nerve cells and gonadal medulla and spermatozoa are more strongly catabolic than anabolic. In cold climates or laboratories invertebrates and vertebrates tend towards larger and more spherical growth with shorter appendages and less heat radiating surfaces, and in warm climates or laboratories the same species tend to more elliptical growth with longer appendages and greater radiation.

It is necessary for biology to analyze the biochemical ratios of each type of cell and organ for its special bidynamic ratio in relation to the equilibratory and imbalancing conditions of its intercellular and extracellular environment, for a better understanding of morphological and physiological differentiations of the organism as a whole in individual development and in evolution of species. Chemical analysis (Tabulae Biologicae, 42) has shown that differentiation in ratios of different chemical elements, in salts, proteins, fats, carbohydrates, and water is carried to remarkable degrees of specialization in each type of receptor, nerve, gland, bone, blood, muscle, and dermal cell in relation to its physiological and morphological specializations and the age of the organism. An additional limited range in compensatory production of new cytoplasmic qualities, under hereditary chromosomal limitations, has been experimentally demonstrated in the form of digestive and immunizing adaptations to special kinds of work, food, and toxins.

Apt illustrations of the counterbalancing ratios of cytoplasmic qualities relative to special activations, nutritions, and eliminations are to be had in the ratios of oxidative substances, such as more stably oxidizing calcium to more unstably oxidizing iodine. In vertebrate cells exposed to constant lines of stress and more simple and slower rates of activation calcium is increased and iodine decreased, whereas in more variably active cells calcium is decreased and iodine increased. A greater ratio of calcium reduces protoplasmic irritability, plasticity, and growth in cartilage and bone but increases its incompressibility and physical and chemical stability, whereas a greater ratio of iodine increases irritability and growth and decreases physical and chemical stability in nerve and muscle. The effects for irritability versus stability are demonstrable experimentally and clinically in excess and deficiencies of parathyroid secretion of hormones for calcium metabolism, and thyroid secretion of hormones for iodine metabolism, and in nutritional intakes.

More exact experimental evidence on the specific counterbalancing allied and antagonistic interactions between cations and anions are given by Heilbrunn (15). Only a few illustrations from cations need be given here. Calcium acts antagonistically to magnesium, sodium, and potassium. Sodium and potassium ions increase cell membrane permeability and increase viscosity of protoplasm, and magnesium and calcium reduce both conditions. Magnesium excess reduces irritability or sensitivity and calcium supports these conditions up to certain concentrations. Too severe reduction of calcium leads to weakness of contraction in smooth, striated, and heart muscle. An excess of calcium lowers basal metabolism.

The differentiation and development of cytoplasm in embryonic cells is bidynamically graded, qualitatively and quantitatively, in relation to quantitative ratios of special activations, nutritions, and eliminations. This is evident in the ratio of catabolic irritability versus anabolic stability in such special forms as sensitivity versus insensitivity, conductivity versus nonconductivity, contractility versus non-contractility, elasticity and plasticity versus rigidity, and grades of assimilative, eliminative, secretive, and reproductive powers.

Adaptive differentiations of cytoplasmic ratios have been demonstrated by experimental transplantations of incompletely differentiated tissues, within species and between species, during gastrula formation (Dürken, 9; Spemann, 41). In the former the cells differentiate in cytoplasmic quantitative ratios to fit the inductive, organizing influences of the new environmental fields within and around the organism; in the latter they do likewise but retain the peculiar qualities of their species for the position.

Witschi (48) has made extensive studies of the effects of different temperatures on the embryonic growth and bisexual differentiation of the Alpine frog *Rana temporaria,* its geographical and climatic distribution and its degree of hereditary chromosomal bisexual differentiation. Hermaphroditic or undifferentiated and weakly differentiated heterosexual variations are found in the Alpine to Baltic range which can be converted into either sex type by extreme temperatures in the natural environment or laboratory. The different tissues of the embryos naturally differentiate and develop at different rates in normal ontogenetic recapitulation of phylogenetically patterned ratios, as determined by the chromosomal genic organization, under their equable range of temperature which is 15° to 21° C. The complexly interrelated and counterbalancing ratios of cytoplasmic differentiation and growth in embryonic organs tend to be disturbed in disproportionate, imbalancing rates and durations, as heat is increased or decreased beyond the equilibratory norm.

As a rule, low temperature accelerates growth and retards differentiation in embryos. In the premetamorphosis stage the bodies are larger, heavier and bulkier with shorter gills and legs and less differentiated livers and kidneys, and the average cell size is increased. In higher temperatures than normal the bodies are lighter than normal, have longer appendages and gills, smaller livers and more highly differentiated kidneys. The gonads in organisms that are sexually equipotential under normal temperature differentiate in cold by retardation of growth of the *M/f* medulla and its medullarin (androgen) secretion and acceleration of the *F/m* cortex and its corticin (estrogen) secretion, producing an *F/m* phenotype with larger ovaries and ovocytes than normal. Heat above normal accelerates *M/f* medullary growth and inhibits *F/m* cortical growth, producing the *M/f* phenotype. Comparable sex differentiations under extremes of cold and warmth are produced in the chromosomally sex differentiated males and females of related races, causing reversal of the ratios of gonadal cytoplasm against the weak heterosexual genic determination, without affecting the latter. The degree of heat is alone sufficient to account for the bisexual differentiation, for sunshine, chemical and geological composition of the soil, precipitation and humidity were found to be unimportant.

Witschi evaluates this evidence as meaning that the gills and kidneys for catabolic waste elimination and the gonadal medulla increase in size and differentiate more rapidly, and the liver for storing metabolites and the gonadal cortex decrease in relative size, as catabolism and oxidation prevails over anabolism under supernormal temperature; whereas the gills, kidneys, and gonadal medulla are retarded, and the liver, gonadal cortex, and body

growth are relatively increased, as anabolism prevails over catabolism under subnormal temperature.

Increase of the gonadal medulla with increase of other more catabolic organs in heat is consistent, for the medulla is more catabolic than anabolic; and increase of the gonadal cortex with the liver in cold is also consistent, for it is more anabolic than catabolic. When hermaphroditic (AA) and chromosomally determined heterosexual ($AAXX$ and $AAXY$) embryos first develop in subnormal temperatures, they all develop gonadally and somatically in the F/m direction, and then upon exposure to supernormal temperatures they gradually reverse in the M/f direction with an hermaphroditic or intersexual interim. The spermatozoa of chromosomally $AAXX$ types are all AX, whereas the spermatozoa of the $AAXY$ types are AX and AY. Eggs fertilized by hermaphroditic sperm, which have no sex differentiated chromosomes, produce organisms with ovaries larger than in fertilizations by heterosexually differentiated sperm. Witschi suggests, from the evidence on gonadal secretions in parabiosis, that this is possibly due to hermaphroditic spermatozoa being cytoplasmically weighted towards greater anabolism by the greater exposure of the spermatogonia to corticin from the female gonad than heterosexual sperm. However this may be, here is indicative evidence of the hereditary transmission of acquired quantitative ratios in the cytoplasm of sperm. It is consistent, although in less degree, with the better known indications of the hereditary transmission of quantitative cytoplasmic modifications through ova.

The effects of different temperature, humidity and other activators on the growth, time, rate, duration, size, of special organs (bristles, wings, body, eyes, color) in mutants of Drosophila having special well known dominant genic determinants, in comparison to wild type as normals, have been studied by Ives (19), Child (6) and many others. They show that special genic determinants of special qualities of cytoplasmic differentiation in special forms of growth are quantified in rate and duration by temperature, humidity, light, and other environmental activators. While heat directly affects both the chromosomes and cytoplasm, humidity, light, and other conditions affect the cytoplasm more directly and the chromosomes indirectly through the cytoplasm.

Child (6) found in general that the duration of effects of heat on growth and differentiation of phenotypic characters, in wild types and mutants and Drosophila, vary for each temperature range, each stage of development, different developmental processes, the two sexes, and for different stocks of chromosomal and genic determination. Mutants are more markedly affected

by slight variations of heat than the wild type, which is only markedly affected by extremes of heat. It is possible to produce by properly timed heat treatment, in the wild type or mutants, non-inherited phenotypes which simulate the phenotypes of known genotypes. The effect of temperature on developmental processes, he points out, is similar to the effect of a mutant gene, that is, both affect the rate and duration of developmental processes and may produce similar phenotypic effects.

The foregoing discussion shows that the experimental evidence on the effects of heat (excessive, equilibratory or normal, and deficient) on the time, rate, and duration of growth and differentiation of phenotypic cytoplasmic and organic characters in Protozoa and invertebrate and vertebrate embryos is consistent with the evidence on organismic position effects in embryonic transplantations (Dürkin, 9; Spemann, 41). This evidence also correlates with the evidence of comparative embryology (Arey, 1) and comparative anatomy (Thompson, 43) as animals or plants adapt to new habitats. It also correlates with the evidence of human and other animal pathological growth under abnormal environmental excitations.

Cytoplasmic Inheritance

The present status of evidence on cytoplasmic inheritance is slight compared to the enormous amount of evidence on chromosomal inheritance. This may be largely due to the greater difficulty in investigating the former and the greater interest in the latter since Mendel's and Morgan's revealing discoveries. Modern studies have been so concentrated on the nucleus and genes that no definite theory has been formed of how cytoplasmic differentiation and determination is produced or how nucleus and cytoplasm interact (Hargitt, 14).

The gametic transmission of directly *acquired* characters is indicated in Protozoa in the form of repeated, long lasting, quantitative, cytoplasmic modifications *against* known chromosomal determinations, by the evidence of Jollos (24), Reynolds (34) and Kimball (27), on cross breeding of types that developed different quantitative cytoplasmic adaptations to special environmental conditions which are differentially excitatory and inhibitory.

The evidence on cytoplasmic inheritance in higher plants and animals has been conservatively considered by Sinnott and Dunn (38). Reciprocal crosses between two related species (male A $\times$ female B and male B $\times$ female A) are generally similar, and variations indicate that the cytoplasm of ova carries hereditary determinants from the maternal side. This has been shown in a variety of forms of life. In plants 20 genera having pale green or white

areas or branches lacking chlorophyll have been described in which the pollen has no influence on the offspring. Non-Mendelian maternal inheritance seems to exist here although in other, similar abnormalities genic determinants have been demonstrated.

In the Rhoades case of male sterility in maize most or all of the pollen (though not the ovules) was aborted. Genic markers for each of the 10 chromosomes were known and each chromosome was successfully replaced by one from normal stock without affecting the sterility, indicating that some agency in the cytoplasm independent of the chromosomes is active. Cases of evidence for cytoplasmic inheritance in reciprocal crosses of herbs (*Epilobium hirsutum* with *E. roseum*) and mosses (*Funaria hygrometrica* with *F. mediterranea*) are also accepted.

In animals, Sinnott and Dunn cite Goldschmidt's theory of sex determination in the moth (*Lymantria*) that male determination is carried in a sex chromosome and female determination in the cytoplasm. Several cases of cytoplasmic inheritance reported for mammals are less definite. The most convincing is that of merogeny reported by Hadorn. He fertilized the egg of the salamander *Triton palmatus* with the sperm of *T. cristatus* and removed the *palmatus* nucleus before fusion. The haploid embryo only developed to the blastula stage but a piece of presumptive epidermis grafted to the embryo *T. alpestris* maintained its identity and developed to adult size and resembled the epidermis of *palmatus* which contributed the cytoplasm. In this instance the cytoplasm and not the nucleus was the dominant hereditary factor. Other cases of merogeny in animals and plants have not been so definite.

In the snail (*Limnaea peregra*) right coiling (dextrality) and left coiling (sinistrality) occur. The direction of the coiling of the phenotype is determined in the second or first cleavage division by the inclination of the spindle in relation to the median line. In sinistrals it is tipped toward the left and in dextrals toward the right. Dextrality behaves as a dominant and sinistrality as a recessive. Some of the snails which are phenotypical dextrals produce sinistral offspring and they have been shown to be homozygous for the sinistral gene. Their dextral character must have been determined by a dextral gene in the mother which determined the nature of the cytoplasm of the egg before reduction, by tending to assymetry of division.

Such illustrations of cytoplasmic inheritance through ova are cases of genic determination of the cytoplasm of germ cells in the mother before reduction division, carrying over into the zygote and early embryonic development, although the conditions are the opposite of the chromosomal-genic

organization of the zygote upon fertilization. Evidence that the genic determination of cytoplasm in germ cells is modified by the environment as in other cells has long been conclusive for plants and lower Metazoa, contra to Weismannism. Evidence is accumulating of such modifiability in higher Metazoa. Bisexual reversals in bipotential frogs under opposite thermal conditions, as previously cited from Witschi, indicate that spermatozoa become cytoplasmically *F/m* through the resulting increase of corticin acting on the germ cells. This is consistent with Willier's (45) finding that germ cells are bisexually equipotential in cytoplasmic constitution and differentiate in the *M/f* direction when during gonad formation they settle in the medulla and differentiate in the *F/m* direction when they settle in the cortex. Evidence for thermo-bidynamic bisexual differentiation in germ plasm has been cited for Protozoa and lower hermaphroditic Metazoa. Evidence of pathological sterility in man and other higher animals indicates that the germ plasm is modified by deficiencies in the blood of any substance necessary for viability or reproductivity, and the nucleus of specific genic enzymes cannot use substitutions in building its cytoplasmic mechanism.

Transplantation of the ovary of an animal homozygous recessive for certain characteristics (white hair or blue eyes) to one of the same species that is homozygous dominant (black hair or brown eyes) does not modify the chromosomes or cytoplasm of the eggs of the transplant. Such negative results are, however, not truly representative of holistic somatic influences against the chromosomal determination, as shown later.

Sinnott and Dunn conclude that the nucleus affects the cytoplasm in many ways and the cytoplasm is the most immediate and intimate part of the environment in which the genes operate. The cytoplasm plays an important part in the origin of differentiation and size of development of different parts of the embryo and serves as minor, secondary means of hereditary transmission, in subordination to the more constant chromosomal-genic mechanism. Cytoplasmic conditions and nuclear conditions are never independent although often so considered when the former behaves contrary to the latter. The influence of the cytoplasm on the nucleus is least known but the evidence is not negative.

We may conclude: It is experimentally established that the organized cytoplasmic ratios of ova and of sperm, although the latter are minute, are formed in the germ cell, before reduction, in line with the genic constitution of the germ cell and the hormonal dominance of the gonad. The latter may be sexually antagonistic, as in sex reversals, or consistent with the genic constitution of the germ cell. The germ cell's chromosomal constitution is

generally not directly modified by the environment, and is equally bisexual or dominant in maleness or femaleness, but its cytoplasm in sex reversals becomes the opposite and holds for the gametes and may extend to the zygote and embryo. Cytoplasmic antagonisms to the chromosomal determination may develop in other cells of the organism, particularly under endocrine influence, more or less modifying the organism's morphology and physiology against the hereditary chromosomal determination.

It is the general conclusion in genetics that all cells of an organism, except the gametes, inherit qualitatively, quantitatively, and positionally like diploid chromosomal complements of highly differentiated and specifically active genic enzymes. Although genes differ in degrees of activity qualitatively and quantitatively, they are probably all more or less active, as allies and antagonists, relative to their chemical constructions and chromosomal positions, for working over and building up special proteins and other substances and rebuilding themselves out of special basic substrates obtained from the cytoplasm. This theory best fits the evidence of breeding phenotypic characters and their correlation with genotypic characters. When, however, the chromosomal-genic organization is claimed to be the *sole determinant* of differentiation and development as well as evolution it fails to include the evidence of experimental embryology, so well shown by Dürken (9). Inborn cytoplasmic differentiations in determinate mozaic eggs before fertilization, and in less determinate eggs after fertilization, and in the blastula of indeterminate regulative eggs, as well as the evidence of embryonic transplantations, eliminations, regenerations, and compensatory reactions to special stimulations, demonstrate capacities in the cytoplasm of germ and soma cells for differentiation and development beyond the chromosomal-genic determination.

The special, *qualitative*, reproductive effects of genic activities on the cytoplasm of interstitial gonad, germ, and soma cells is shown, by the foregoing evidence, to be *quantitatively*, adaptively regulated by the ratios of different substrates obtained from and returned to the cytoplasm, which are determined by two additional factors: (*a*) the ratio of cytoplasmic inheritance from ancestral cells, back to the zygote, ovum, or sperm and germ cell cycle, and (*b*) the long continued ratios in the blood of special kinds of metabolites (hormones, organizers, proteins, ions) in reaction to special ratios of more repetitious, intercellular and extracellular, environmental, excitatory or inhibitory, physical, electrochemical, nutritional, and eliminative conditions.

The differentiation and development of special types of cells are largely

determined, as embryonic transplantations and eliminations have shown, by interactions with other cells of the same and different kinds in that field interactive with other fields in forming the organism and organs, through the production of special ratios of special electrochemical excitatory and inhibitory agents and pressures and tractions in special lines and planes of force. Hence the quantitative ratios of cytoplasmic qualities in different kinds of cells are all interactive, interdependent and integrated while the constant chromosomal-genic organization limits their qualitative productions. Graded reductions of special properties towards minus and increases of one or two properties, as found in all specialized cells, makes each type dependent on the products of other cells. No new cytoplasmic property is created in the organism by genic action. All cells use the same blood supply for nutrition and elimination but use different ratios of anabolites. The differentiated sensory cortex, for instance, is the product of special quantitative ratios of special protein substances having special irritabilities or instabilities. Thereby the differentiation and development of the field of speech is extero- and proprioceptive stimulation conditioned.

Embryonic cells tend to differentiate cytoplasmically from reversible to irreversible and from reproductive to unreproductive ratios with one or two major properties dominant, in ontogenetic recapitulation of phylogenetic orders characteristic for the species and the parentage. Strongly anabolic and weakly catabolic cells (epidermis, germ, gland, blood-making and connective tissue) retain cytoplasmic ratios that have high reproductivity so long as they have adequate nutritional support and elimination with stimulation, whereas cells that are weakly anabolic and strongly catabolic (receptor, nerve, muscle) lose reproductivity but have higher irritability.

Environmental and Cytoplasmic Modification of Genes and Chromosomes

The Lamarckian term "inheritance of acquired characters," still in general use in biology, is too indefinite for satisfactory discussion unless one bears in mind that the Lamarckian scheme does not work and most acquired characters are not inherited, being somatic reaction changes that do not completely affect the whole organism and force submission in its self-righting compensatory resistances.

Many biologists still hold that the chromosomal organization in germ cells is immune from cytoplasmic modification and is the sole determinant of evolution as well as an "unfolding" development, for want of conclusive evidence that acquired characters in the cytoplasm are inherited.

Resortment in the diploid chromosomal genic organization naturally attends crossings in many genic and chromosomal allelic pairs between the complement inherited from the father and that from the mother, forming new chromosomal-genic organizations containing, under Mendelian ratios, dominant and recessive unit characters from both parents. Haploid reduction meiosis follows in gamete formation, and a diploid complement is restored upon fertilization of the ovum by a spermatozoon. The zygote then has a new chromosomal-genic organization with parts determined by four ancestors. Since these dominant and recessive units seem to be qualitatively and quantitatively constant such resorting in a large number of genes without changing relative positions in chromosomes tends to produce innumerable variations of genotypes and phenotypes within species which are limited by viability and reproductivity to a definite phylogenic pattern. Sudden more or less extensive mutations as qualitative changes in genes or as augmenting allied or reductive antagonistic positions in the chromosomes may also occur during the phase of resortment and crossing. When by chance they are not lethal or sterile and fit effectively into the phylogenetic pattern they may produce fertile phenotypic changes that are great enough, upon environmental isolation with similar phenotypes in mates carrying harmonious genotypes, to build further changes until they gradually produce a new species that becomes isolated by genotypic barriers. Hence it is held that variations are produced by the resorting of hereditary unit characters but species originate entirely through the orderly accumulative organization of chance minor genic and chromosomal mutations.

The following evidence shows that environmental modification of cytoplasmic ratios may possibly produce genic and chromosomal modifications, with indications of selective determination. If this is true the evolution of life is based on autogenously pragmatic as well as chance factors, as indicated by the evolution of increasing autogenous regulation of bisexual differentiation and reproduction with somatic powers against environmental interferences.

About five times more genic mutations occur in Drosophila in a given time at 10° C. above normal temperature than at normal temperature, but chromosomal translocations are much less frequent under increased heat (Plough, 32). Extreme temperatures may increase polyploidy in animals and even more so in plants (Fankhauser, 11). Quantitative then qualitative changes in genes seem to be first in order, and their chromosomal positions and linkages are the last and least affected. This difference in thermal effects seems to be similar to the shocking effects of other radiations.

The metabolism of a cell in mitosis no doubt differs qualitatively and quantitatively from a resting or working cell and the metabolism of meiosis differs in some ways from mitosis, with other physico-chemical conditions similar. Some phases of the chemistry of mitosis have been analyzed and they indicate somewhat how radiations (roentgen, radium, ultraviolet, heat) and chemicals act on chromosomes and genes and cause mutations upon crossing over of parts. The simple hit-break theory, so long assumed in genetics, is that protons or electrons hit chromosomes by chance and produce mutations as the result of breaks and translocations, or hit genes and produce chemical transformations. This theory has been losing confidence since it has been demonstrated by Duryee (10, cited by Heilbrunn, 15) that frog eggs show chromosomal effects when exposed to only 1000 *r* units of roentgen irradiation but similar nuclei when isolated show no effects after exposure up to 50,000 *r* units. This evidence indicates clearly that the primary effects of radiation are on the cytoplasm where they cause a release of calcium (Heilbrunn and Mazia, 16). The chemical production of genic mutations must obviously proceed first through cytoplasmic substrates.

Dürken (9) has given an excellent illustration of a holistic acquired modification that became permanently hereditary. A female guinea pig, of a breed that for many generations had produced normal, sound eyes, was mated with its brother and given naphthalene, a poison that injures the retina and causes opacity of the cornea in particular with other general effects. A male and female were born, the male showing stunted development of the eyes. This male was mated to a normal female of sound eyed stock and the next generation (F_2) produced all females of sound eyes. These were back crossed with the father (F_1) and produced six males and three females. One of the latter had an eye defect like the father. Continued inbreeding up to the sixth generation produced only females with stunted eyes. In the seventh generation a defective eyed male was born which died before it could be used for breeding. In the tenth generation another defective eyed male appeared which upon crossing with the defective females established a new breed in which all descendants have stunted eyes. They are homozygous recessive for certain eye determinants. Dürken's interpretation is that naphthalene toxic products in the maternal circulation damaged some of the primordial tissue cells of the embryos which produced defective development of the eyes. This condition was attended by a loss or injury mutation to the hereditary reaction basis of the germ cell nucleus (chromosomal genic organization) which was recessive and manifested phenotypic effects upon becoming homozygous.

The genic loss mutation seems to have followed changes in special cytoplasmic substrates in the embryonic germ cell. This series of changes attended but was not produced by a qualitatively related cytoplasmic injury to eye primordia in the developing embryo, and both effects began with special qualitative and/or quantitative effects of naphthalene poisoning in the maternal circulation which permeated the embryonic circulation. Such evidence indicates how climatically fitting acquired characters may become hereditary and differentiate races in man and other forms of life.

Many speculative explanations on cell division have been attempted but it is now realized that none can be satisfactory because of the vast amount of still unknown physical and chemical steps involved. Heilbrunn (15) has shown the importance of cytoplasmic calcium in cell division and indicated how it may affect the chemical balance in chromosomes. Any protoplasmic stimulant can act in inducing cell division, where such capacities are retained, hence these processes are probably not far different from other processes of stimulation and reaction generally. Calcium is released in the cell cortex upon stimulation and moves centripetally in the protoplasm with gelling effects. Calcium release, as a result of fertilization or artificial activation of the egg, initiates the clotting or gelation which leads to the formation of the mitotic spindle. Mitotic gelation apparently involves a decrease in the solubility of cell proteins and bears a resemblance to blood clotting which is dependent on the liberation of calcium. Thrombin increases cell mitosis, and the artificial reduction of calcium or the addition of heparin reduces cell mitosis.

Heilbrunn's explanation is that positively charged ions tend to neutralize the normal negative charge on the chromosomes which holds them apart, and they become sticky. This effect is increased when the nuclear membrane is especially permeable or has disintegrated and the chromosomes are free in the cytoplasm, late in the prophase of mitosis.

The ratios of the different cations and anions in the cell are not entirely independent of the ratios of special metabolites in the blood, and the ratios of special ions in the cell are interdependent. Long continued excesses or deficiencies in such metabolites tend to influence compensatory substitutions in the ratios of special substances in gonad and germ and soma cell cytoplasm according to their special constitutions. Although germ cells are probably free from direct nervous regulation and are more resistant to metabolic changes, the isolation is not as complete as generally held since Weismann. The evidence for calcium effects on chromosomal crossing indicate that excesses in some special ionic or protein substrates and deficiencies in others might

have specific effects on the quantitative reproductions hence crossings of special genes and parts of chromosomes. Hence mutations might be less a matter of chance and environmentally more determined than heretofore thought. The inheritance of acquired characters would not occur in gross morphological changes, as was once assumed, but in the form of special quantities of special qualities of cytoplasmic properties. Under special, continuous environmental conditions such inheritance would more readily repeat special morphological and physiological changes. An illustration would be the inheritance of increased capacity for developing immunity to a special agent like measles or small pox which seems to be greater in collective civilized than isolated primitive peoples.

Thermo-Bidynamic Origin of Bisexual Differentiation

The bidynamic constitution of the cell and the decisive differences for the thermodynamics of life of structuralized energy and free energy, the strong or weak quantitative ratios of special anabolic and catabolic properties in chromosomes and cytoplasm, the ratios of male and female genes in chromosomes of haploid gametes, the chemical drive (from imbalances) for union with self-preservation of viability and reproductivity in the gametes of unicellular and multicellular animals and plants, the differences in rates of activation of anabolic and catabolic processes by heat far more than other environmental factors, and the hereditary transmission of acquired cytoplasmic ratios and their possible effects on hereditary chromosomal reorganization, are sufficient evidence for the construction of a theory of the thermobidynamic origin and evolution of bisexual differentiation.

The origin and evolution of bisexual differentiation must be consistent with other somatic, cytoplasmic differentiation, since different parts of the same chromosomal complements are more or less active in both. The autogenous$\times$exogenous processes that originally differentiated protozoan cells bidynamically and reproductively have continued to carry on such differentiation in the evolution of Metazoa.

Dominant or strong and recessive or weak allelomorphic genes are qualitatively related but contrast quantitatively, as more or less, in each individual of a species, hence may be expressed relatively in ratios of plus and minus. The summation of genic, allied and antagonistic, differentiating effects upon the anabolic or catabolic side of cytoplasm also varies in plus or minus directions.

Nuclear and cytoplasmic properties are evidently interactive, and whatever their differences they sum up in the anabolic and/or catabolic ratios of the

cell which works holistically to acquire energy and use it for viability and reproductivity. The bidynamic ratios of cells, and of organisms of cells, determine their balance for viability and reproductivity. The ratios of the aggregates of anabolism and the aggregates of catabolism of individual cells and of organisms range from equally strong to equally weak, to little or much stronger or weaker than necessary for equilibration. The total strong and weak nuclear and cytoplasmic anabolic to catabolic properties in all living things, including unicellular organisms and multicellular organisms as wholes and their gonads and gametes as parts, may therefore be represented as relatively plus or minus. The quantitatively strong aggregates of cellular anabolic factors may be symbolized as more or less $A+$; and weak aggregates of anabolic factors as more or less $A-$; and strong aggregates of catabolic factors as more or less $C+$; and weak aggregates of catabolic factors as more or less $C-$. To illustrate: the cytoplasmic bidynamic ratios of germ cells, at least in hermaphrodism and reversible heterosexualism, are equipotential and differentiate in ratios that are unipotential after settling in the medulla or cortex of the gonads. They become, respectively, $A-C+$, M/f, or $A+C-$, F/m.

The quantitative ratios and qualitative intensities of anabolism and catabolism of the cell are differentiated and graded by increases or decreases (beyond an equilibrating mean peculiar to its chemical constitution) of special environmental energies, as they augment or reduce the rate of autogenous activation of special parts and properties of the cell more often and more intensely than others. This rule applies to animal or plant cells of any type and is the basis for the adaptation of growth and differentiation of solitary or colonial unicellular organisms, or cells in multicellular organisms. In the cell as a bidynamic whole, external equilibrating conditions are catabolically reductive or inhibitory, and thereby relatively increase the ratio of anabolism. Excitatory and other activating environmental variations relatively increase catabolism and thereby decrease the ratio of anabolic resources. Generally, a greater rate of anabolism over catabolism produces greater, undifferentiated growth and larger size of cells, with increase of reproductivity; whereas greater catabolism than anabolism produces greater differentiation and smaller cells with more dependence on nutritional support from other cells, and reduction of reproductivity.

Increase of heat, exogenously or autogenously, within viable limitations, more than any other activating factors, accelerates, intensively and extensively, more active, rapidly oxidating, energy-releasing, heat-producing catabolism faster than less active, heat-absorbing, energy-upbuilding, slowly

and slightly oxidating anabolism, and produces a catabolic dominance with anabolic deficiency or an $A-C+$ bidynamic ratio. In striated muscle the rate of oxidative catabolic contraction is 120 times as intense as oxidative anabolism (Bard, 3). Thermogenic differentiation probably follows the chemical law of doubling for each 10° C. This tends, in germ cell equipotential M/F bisexuality, to make a M/f cytoplasmic differentiation, in Protozoa, and in germ cells, gonads and gametes of Metazoa.

Decrease of heat under the equilibratory mean (cold) retards the rate of catabolism more than anabolism and produces anabolic dominance, or an $A+C-$ ratio, tending to F/m cytoplasmic differentiation.

Variations in light and humidity, and strong and weak contact stimuli, and chemical activators and inhibitors, have comparable though weaker differentiating effects which may summate with or oppose and reduce heat effects. They are, however, chemically too limited or specialized to produce the universality of bisexual differentiation, although they influence other somatic, cytoplasmic differentiations as they are converged repetitiously on the outer surface (ectoderm) or inner surface (entoderm) or internally (mesoderm).

Environmentally acquired modifications of inherited cytoplasmic ratios evidently *quantify*, in proportion to their depth and extent, the reproductive *qualitative* effects of more stable hereditary chromosomal and genic determination, producing a limited elastic range in the adaptations of learning and growth for ontogeny and phylogeny. Hence any synthesis of the origin and evolution of differentiation of the bisexual ratio must be based upon the sensitive, equipotential $A+C+$ bidynamic ratio of primitive protoplasm or of the whole cell, and its inclusion of the inherited M/F bisexual ratio in cytoplasm and nucleus, and the acquired thermal and other environmental modifications of cytoplasm producing possible quantitative and qualitative modifications upon the reproduction of genes and their organizations in chromosomes.

The grades of viability and reproductivity of the anabolic/catabolic organization of living things naturally divide them into four, major, constitutional bidynamic types or ratios. These exist in unicellular species, and in the gametes, zygotes, and cells of organisms, and organisms as wholes, of each multicellular species. They include the strong anabolic and strong catabolic, $A+C+$ or *hardy*, well balanced, vigorous ratio; the strong anabolic and weak catabolic, $A+C-$, more *hypokinetic* ratio; the weak anabolic and strong catabolic, $A-C+$, more *hyperkinetic* ratio; and the weak anabolic and weak catabolic, $A-C-$, *weakly viable, unreproductive* ratio.

If four major bidynamic ratios or types are naturally produced in unicellular as well as multicellular animal and plant gametes, how then do they differentiate into two complementary reproductive or sex types and other infertile types And how do the reproductive types grade in viability and reproductivity, producing zygotes and organisms ranging from vigorous fertility, to sterility of supersexes and intersexes, to lethal abortions? For simplification we will first consider unicellular differentiation, then multicellular gametic differentiation and last multicellular organismic differentiation.

The bidynamic ratios of cells as wholes include, as previously said, the chromosomal and the cytoplasmic bisexual ratios, which chemical and thermal sex reversals show are not always consistent. Hence symbolic designation of the ratios of the whole and of its chromosomal and cytoplasmic parts is necessary for discussion of their differentiation in bisexual evolution. A or C is obviously not to be identified with M or F, but the ratio of A to C includes the ratio of M to F.

In unicellular organisms the hardy, equipotential $A+C+$ ratio is able to reproduce without conjugation until it becomes, under thermal, luminary or chemical differentiation, either an unbalanced $A+C-$ or $A-C+$ ratio or a weak, sterile $A-C-$ ratio. These three end types of mitosis will disintegrate unless they can reorganize themselves or conjugate with fitting complementary opposites. The autogenous selection and conjugation of an $A+C-$ type with an $A-C+$ type produces an $A+C+$, rejuvenated, reproductive, well balanced, bidynamic zygote provided that potentially lethal genic combinations do not exist in their chromosomal complements. The conjugation of any other run down combinations produces a too severely imbalanced ratio with either anabolic or catabolic weakness, tending to weak viability and reproductivity, hence self-elimination. More than two mating types have been described by Jennings (21) and Sonneborn (40) for Paramecia. They probably constitute subtypes within the $A-C+$ and $A+C-$ ranges of reproductivity.

This reproductive, autogenously selective, bidynamic, differentiating process applies equally well to metazoan germ cells, gametes and zygotes. Germ cells reach the end products of division in fertile ova as the $A+C-$ type or fertile sperm as the $A-C+$ type and infertile ova or sperm as $A-C-$ types. The union of an $A+C-$ with an $A-C+$ gamete produces the $A+C+$, reproductive zygote, provided the genic combinations are favorable. Too great chemical displacements within the bidynamic ratios of zygotes become lethal or sterile in embryonic growth and segregate genotypes to reproductivity within species and sometimes within varieties.

Parthenogenic metazoan ova must be strong in both ratios, approaching the equalization of non-parthenogenic zygotes, but are characteristically stronger on one side than the other for they produce only one sex. The parthenogenic, haploid growth of male bees and the parthenogenic, haploid growth upon catabolic shock, of female rabbits (with rudimentary male organs), indicates that a viably adequate although not equal ratio of anabolic/catabolic factors has been retained in the ovum which differs quantitatively from the ratio of diploid zygotes. As bidynamic differences increased in gametes, union became increasingly necessary for fertile reproduction in successive generations. Artificial parthenogenesis in mammals does not contradict this generality.

Autogenous selection in metazoan gametes, as in protozoan gametes, of unfit, lethal or sterile anabolic/catabolic combinations results in elimination; whereas the selection of opposite, complementary, viably bidynamic and potentially fertile, bisexually differentiated ratios or types is reproductive. The same principle applies to fertilization in plants. We may now follow the A/C ratio of thermal bidynamic differentiation and its inclusion of the bisexual M/F ratio of cytoplasmic and nuclear differentiation and its inclusion of the bisexual ratio of chromosomal-genic differentiation $AAXX$ and $AAXY$ through unicellular and multicellular hermaphrodism to heterosexualism.

Zygotes or germ cells of some Protozoa and some primitive species of algae are bisexually equipotential and seem to reproduce in either the male or female direction in response to quantitative differences in activation by environmental conditions (Danforth, 8). Such equipotential zygotes or germ cells may be assumed to be bidynamically $A+C+$ and bisexually M/F with no effective bisexual differences in their chromosomes. But their gametes become male with $A—C+$ bidynamic and M/f bisexual ratios, and female with $A+C—$ and F/m ratios.

These conditions extend to multicellular plant and animal functional hermaphrodism. The zygote is also equipotential $A+C+$ and M/F, and a similar $A—C+$, M/f ratio exists in the sperm and an $A+C—$, F/m ratio exists in the ova. Quantitative differences in the bisexual ratios of chromosomes and genes begin to emerge in amphibians as shown by hermaphroditic and heterosexually reversible frogs.

Sperm and ova of Protozoa and Metazoa have opposite quantitative ratios of anabolic and catabolic *cytoplasmic* qualities, in hermaphrodism and in heterosexualism. In hermaphrodism the bisexual ratios of genes in each of the two strings of chromosomes seem to be equal, whereas in heterosexualism

bisexual chromosomal differences appear and increase, and are attended by increasing gonadal differentiation in the evolution of amphibians to reptiles to birds and reptiles to mammals (Witschi, 47, 48).

Heterosexualism evidently evolved from hermaphrodism with progressively increasing bidynamic and bisexual differentiations in the cytoplasm of the germ cell—gamete—zygote—gonad—germ cell cycle, as autogenous determination against environmental imbalances accumulated in reproductive selection.

Such adaptive, accumulative, cytoplasmic differentiation probably led, within viable and reproductive limitations, to some slight, one sided, quantitative (dominant-recessive) variations, followed by qualitative variations in the diploid genic reproductions during meiotic chromosomal crossing and reorganizations. These genic changes predisposed, through the greater economy and potency in the reorganization of more closely allied position effects, to bidynamic chromosomal translocations with the tendency to more economical same-sex gene convergence through linkage in one chromosome (known as X) with less in its opposite (Y) and opposite sex gene distribution in the autosomes (A) (Bridges, 4). All ova and half of spermatozoa in many species (fishes, mammals) are alike in sex chromosomes, and half of ova and all of spermatozoa are alike in others (fishes, birds). The mammalian ovum has a bisexual F/m ratio with AX chromosomes and an $A+C-$ holistic, bidynamic ratio. The AX spermatozoon has also an F/m chromosomal ratio but an $A-C+$ bidynamic ratio because of its M/f cytoplasm, whereas the AY sperm is chromosomally M/f with an M/f cytoplasm hence is even more strongly $A-C+$. The latter combination seems slightly more active since more males than females are born, hence probably more fertilized.

Zygotes differentiated progressively from the equipotential hermaphroditic $A+C+$ bidynamic, M/F bisexual, AA chromosomal pattern to the heterosexual $A+C++$, M/f, $AAXY$ male and $A++C+$, F/m, $AAXX$ female pattern in evolution in the mammalian direction. In birds the zygotic differentiation is $A+C++$, M/f, $AAXX$ for males and $A++C+$, F/m, $AAXY$ for females.

Every grade of hermaphroditic bifertility to heterosexual unifertility and supersexual and intersexual sterility is explainable on the same plan, as grades of more or less reproductive anabolic/catabolic ratios. Complete balance of bisexual M/F and of anabolic/catabolic ($A+C+$) factors in the chromosomes and cytoplasm of the zygote is characteristic of bifertile, hermaphroditic species and of sterile intersexuals in heterosexual species,

which are forms of regressive hermaphrodism. Intersexual flies and moths have been interpreted by geneticists (Goldschmidt, 13) as resulting from too complete equilibrium in male and female determinants in chromosomes and cytoplasm. Sterile superfemales seem to result from an overweighting of strong anabolic over a viable strength of catabolic factors $(A{+}{+}{+}C{+})$ and sterile supermales follow from an overweighting of strong catabolic factors over a viable strength of anabolic factors $(A{+}C{+}{+}{+})$.

Androgens are more oxidative than estrogens, and the $AAXY$ chromosomal complement seems to be more oxidative than the $AAXX$, and male phenotypes generally have stronger catabolism than female phenotypes. The difference in rate of growth of the cortex and medulla of the gonads and their quantitative production of the two hormones (corticin or estrogen and medullarin or androgen) increases with increasing bisexual differentiation in the chromosomes. The M/f chromosomal complement is a more active determinant of gonadal growth than the F/m. Cortin (from the adrenal cortex) is also more androgenic than estrogenic, and excessive heat is more actively oxidizing than deficient heat, and catabolism in any form is more oxidative and thermogenic than anabolism. Herein autogenous chemical and thermal kinesis have an allied, determining, oxidative action on bisexual differentiation. They may summate with exogenous heat and other chemical oxidative effects and become adequate for fertility; or they may become excessive and sterilizing; or they may oppose exohormonal and/or exothermal effects which, if stronger, determine the direction of cytoplasmic bisexual differentiation against the chromosomal determination.

Laws of thermo-bidynamic bisexual differentiation may now be formulated from the foregoing as follows:

1. *The cytoplasmic effects of equipotential chromosomal bisexuality are differentiated in the* $A{-}C{+}$, M/f *direction by increase of heat over the equilibrating mean and/or by androgenic substances; and are differentiated in the* $A{+}C{-}$, F/m *direction by decreases of heat under the equilibratory mean and/or by estrogenic substances.*

2. *As the ratio in bisexual chromosomes increases, the ratio of bisexual differences in gonads and hormone production increases in the same direction, and the cytoplasmic reversing effects of opposite sex hormones and opposite variations in environmental heat decrease.*

3. *The determining effects on the bisexual differentiation of cytoplasm by heat, chromosomes or hormones may be allied and consistent or antagonistic and reversing and variously confusing to growth in its transitions from hermaphrodism to heterosexualism.*

THERMO-BIDYNAMIC EVOLUTION OF BISEXUAL DIFFERENTIATION

The long, slow evolution of lower to higher metazoan hermaphrodism to heterosexualism passed, in the vertebrate direction, through a series of stages of increasing power in chromosome differentiation, producing a more decisive cytoplasmic differentiation of gonads and gonoducts and an adrenal cortex that supported an increasing autogenous, neurohumoral thermal regulation to counterbalance the cytoplasmic sex-reversing effects of exogenous thermal variations. These stages include simultaneous, self-fertilizing hermaphrodism, alternating, cross fertilizing hermaphrodism, potentially bifertile, reversible heterosexualism, and unifertile, irreversible heterosexualism. These steps are summarily presented here to outline the evolution of bisexual differentiation. A more complete presentation in relation to its ontogenetic recapitulation in man has been presented in other papers (Kempf, 25, 26).

In equipotential, self-fertilizing hermaphrodism (hydra, sponges, worms), fertile, sex-differentiated gonads exist concomitantly, hence the bidynamic ratio of the zygote is $A+C+$, its chromosomal bisexual ratio is AA (for no sex differentiated chromosomes exist) and its cytoplasm is equally M/F. The gonadal and germ cells have like diploid chromosomes but become cytoplasmically differentiated by differences in external heat and electro-chemical substances due to their special positions in the organism and external environment. The female gonads, germ cells and ova become bidynamically $A+C-$ and cytoplasmically F/m relative to the male gonads, germ cells and sperm which have become $A-C+$ and M/f. Since experimental cross sections of the whole organism reproduce whole, bifertile, bigonadal organisms the cytoplasmic differentiation in special cells is weak and reversible without chromosomal limitation as to sex or other characters.

In annually breeding, alternating, or reversible cross-fertilizing hermaphrodism (mollusks and such lower vertebrates as lampreys) evidently greater bisexual cytoplasmic differentiation exists in the gonads and germ cells for they develop alternately in M/f and F/m ratios, probably still with little resistance in chromosomal bisexual differentiation. These conditions suggest that *heterosexual genic and chromosomal differentiations in germ cell meiosis gradually followed such cytoplasmic differentiations as derivatives rather than as antecedents or attendant accidents,* as still held by most geneticists.

In reversible heterosexualism (poikilothermic fishes, eels, amphibians and probably reptiles) potentially bifertile M/F gonads exist, but in equable thermal conditions dominance of cortical or medullary growth, as a weak chromosomal differentiation determines, holds the other in rudimentary inhibi-

tion. A decreasing reversibility or increasing resistance to thermal reversal has evolved here. In Witschi's Alpine and Baltic frogs the F/m heterosexuals become partly reversed to hermaphrodism or completely reversed to M/f as graded by exothermal fluctuations during the larval stage of differentiation, and the M/F hermaphrodites can be converted to M/f males by exposure to supernormal heat during similar periods of growth. In exothermal bisexual differentiation the cold of early spring produces more females than males and the warmth of late spring produces more males than females, consistently with or in reverse to the chromosomal determination, resulting in great inequalities in the ratio of sex populations in unseasonable thermal variations.

The preceding evidence shows that in reversible heterosexualism the range of environmental heat above the equilibrating mean determines an $A{+}C{+}{+}$ bidynamic differentiation of the embryonic organism and an M/f gonadal differentiation and heat below this mean determines an $A{+}{+}C{+}$ bidynamic organism and an F/m gonadal differentiation, in weakly thermogenic animals that have a weak $AAXY$ or $AAXX$ chromosomal differentiation. This reversible level of bisexual evolution is an improvement in self-determination upon alternating hermaphrodism. Progressive chromosomal sex differentiation is found in fishes and amphibians but the differences are not as strong as in more highly thermogenic birds and mammals. Chromosomal determination of the differentiation of the adrenal cortex from the urogenital ridge in support of autogenous heat production and conservation is also still very weak but not entirely negligible.

Reptilian bidynamic, cytoplasmic and chromosomal sex differentiation became greatly extended in birds. Here the chromosomal bisexual differentiation seems to be nearly as highly developed as in mammals, but the ratio of the gonadal differentiation remains reversible. The adrenal cortex support of thermogenesis seems inadequate in the embryos, who are thermogenically inconstant and dependent upon parental thermal support with additional solar support. Elimination by disease or surgery of the left, completely differentiated, F/m ovary in hens lets the right, incompletely differentiated, M/f testis-ovary develop. Fowls then not infrequently undergo reversal from F/m to M/f in organismic sex characters with production of fertile sperm instead of eggs.

The evolution of ovoviviparous reptiles to viviparous, placental, mammalian marsupials to true placentals seems to have been dependent on the concomitant evolution of a stronger chromosomal bisexual differentiation and its determination of a decisive, unifertile gonadal bisexual differentiation,

accompanied by a greater adrenal cortical and neural (hypothalamic and cerebral) means of regulation of heat production and radiation towards increasing constancy of body temperature against environmental fluctuations of heat. In mammals, increasing capacities for regulation of heat production and radiation evolved from monotremes to marsupials to rodents, ungulates, carnivores, to the anthropoids, culminating in man. The progressive, bisexual chromosomal differentiations have been accompanied, no doubt, by increasing chromosomal determination of the growth of organs for heat production and conservation and nephritic elimination of metabolic wastes.

It is evident that in birds and mammals the bidynamic ratio of the male zygote has become increasingly $A+C++$ and the chromosomes and cytoplasm more strongly M/f, whereas the female has become more $A++C+$ and the chromosomes and cytoplasm more strongly F/m. This has determined a greater bisexual gonadal differentiation hence organismic differentiation. The degree of resistance to exothermal sex reversal in placental embryos has not been reported, but increasing resistance to hormonal reversal is indicated in carnivores and anthropoids over ungulates and rodents (Witschi, 47).

Protracted excessive heat is sterilizing for M/f and F/m germ cells of all species. This produced a special problem for life as autothermogenesis reached a higher and more constant temperature. As previously noted, androgenic metabolism is more highly oxidative and thermogenic than estrogenic metabolism, and the M/f chromosomal constitution is probably more highly oxidative than the F/m. $A+C++$, M/f phenotypes are thermogenically higher and more constant than $A++C+$, F/m phenotypes, and both are higher in estrus than in diestrus. The body temperature of male higher mammals is sufficient to sterilize the germ cells of the more active male gonads whereas in females the normal body temperature supports the internal retention of the gonads, ova and embryos. This consistently supports the theory that sex differentiation is basically a thermal differentiation of bidynamic ratios. In lower mammals, as autothermogenesis and gonadal and chromosomal intensity increased, sterilization was prevented by temporary migration of the testes outside of the body into thermally reductive scrota during seasonal estrus (Moore, 30). In higher mammals the evolution of higher thermogenic constancy was attended by greater estrual frequency, and early, permanent scrotal descent of testes. This course in evolution is consistent with exothermic, bidynamic, bisexual differentiations of amphibians and other poikilothermic animals.

The evolution of bisexual chromosomal and gonadal differentiation is accompanied by evolution in the regulation of heat production and radiation

as a supporting, counterbalancing factor against sex reversal or sterilization by extremes of environmental heat. Up to the vertebrate level the adrenal cortex seems not to have been differentiated. In fishes two small separate adrenal glands exist, one of mesodermal origin derived with the mesonephros and gonads from the urogenital ridge, and the other of ectodermal origin derived from sympathetic nervous ganglia (Shumway, 37; Arey, 1). The former is known as the adrenal cortex and the latter as the adrenal medulla since in mammals the former surrounds the latter to form the adrenal gland as it migrates to the upper pole of the kidney. They continue to function separately but with remarkable reciprocity in the regulation of heat production.

The adrenal cortex seems to be more closely related to the gonadal medulla than the gonadal cortex, for its hormone (cortin) is more androgenic than estrogenic and has *M/f* differentiating cytoplasmic effects upon the growth of the genitals, skin, hair, and other sex characters and on sex behavior. Cortin is indispensable for maintaining a high rate of protein-oxygen catabolism in nerve and muscle for heat production and work. Through its effect on hair and feather growth it also influences heat conservation and radiation. Cortin deficiency in man and other mammals is followed by low heat production and thermal inconstancy with reduction of resistance to either extreme of heat or cold. It is indispensable for gamete production and pregnancy in placentals (Wolf, 49; Hoskins, 17) and basic for life itself in all vertebrates. In the human embryo the adrenal cortex is at one time more than one-third as large as the kidney (Arey, 1). It then recedes in size (prenatally and postnatally) relative to the kidney and other organs. Heat regulation in the fetus becomes increasingly autogenous and supportive of the chromosomal and gonadal determinants of sex differentiation. The degree of heat radiation from the mother to the fetus is no doubt physiologically inadequate for the needs of embryonic growth and bisexual differentiation.

The origin of the adrenal cortex and gonads from the same part of the urogenital ridge suggests a closely related chromosomal determination. Since the adrenal medullary hormone (adrenin) supports the sympathetic system and hypothalamus in the neuromuscular regulation of heat production and radiation, the union of the glands over the kidney indicates the importance of economy in quantity, quality, space and time or form, rate and duration of use of energy as well as in capturing and building energy, in the higher evolution of the mechanistic organism for greater self-regulation of heat production and radiation, work and reproduction.

ONTOGENY OF BISEXUAL DIFFERENTIATION

Every cell, every organ and the organism as a whole and all its functions are (*a*) bidynamically, (*b*) chromosomally and (*c*) hormonally bisexually differentiated. The holistic organization of functioning of the organism producing the personality is also (*d*) attitudinally socially stimulation-conditionally bisexually differentiated. All of these four differentiators may be in harmony with one another and consistent with the basic chromosomal differentiation, producing healthy, happy, efficient functioning. Or, any of these differentiators may be antagonistic with more or less neurotic and arresting or regressive and confusing effects on organismic growth. Social bisexual differentiation may be in harmony or in conflict with a normal or abnormal organismic bisexuality and productive of a serious neurosis. Hence the physician must estimate the degrees of influence of all four differentiators in his patients. The bidynamic differentiation is shown in the energy for self-determination against oppositions. The chromosomal bisexual differentiation is manifested in the family heredity. The gonadal hormonal and adrenal thermogenic hormonal effects are shown in the bodily characters. The attitudinal and social differentiation is shown in repetitious compulsive emotivations.

Self-preservative functioning and bisexual functioning do not work separately in life. The organism works through the organization of functioning to produce attitudes giving a stream of consciousness-of-self-in-environment for equilibrating the needs of its different organs as they arise, but normally all parts function interactively as a whole for self-preservation of maturation in the reproductive direction.

The ontogeny of man like other animals recapitulates its phylogeny in an orderly series of steps from zygote through organismic development to senility. These steps include the prenatal differentiation of the gonads, gonoducts, and cloacal-perineal organs from hermaphrodism to heterosexualism (Kempf, 26). The postnatal differentiations include the slower conditioning of the cerebral cortex in lower to higher integrative consciousness-producing levels by the internal physiological and morphological order of changes interactive with steps in the exogenous, bisexual socialization of the developing organization of the personality. Such differentiation proceeds in an orderly sequence of stages.

(*a*) The primal, autoerotic, self-love-making through learning oral, anal, urethal, genital, manual, autonomic-affective and somatic-kinesthetic attitudinal, verbalizing and symbolizing arts from infancy through puberty, recapitulating the behavior patterns of self-mating hermaphrodism.

(*b*) The alternating homosexual attitude and love-making interests of dominance or subordination with a weaker or stronger same sexed mate, recapitulating patterns of cross-mating hermaphrodism.

(*c*) The weak stages of heterosexualism reversible upon frustration to homosexualism of postadolescence, recapitulating the reversible heterosexualism of lower evolution.[1]

(*d*) The stage of irreversible heterosexualism of morphological, physiological and psychological maturity.

(*e*) The tendency to regression towards intersexualism in senility or upon castration.

Neurotic autonomic-affective regression towards intersexualism upon heterosexual frustration, tending to cloacal hermaphrodism in chronic, malignant dissociation of the personality (dementia praecox), seems to be a deep emotional reversal of the ontogenetic recapitulation of the phylogenetic order.

Evolution in the Ratio of Energy Used in Reproductivity and Work

Complementary, interdependent, opposite, bidynamic bisexual ratios exist in plants as well as animals, which must be explained by the theory of evolution. Thermal differentiation probably exists here in combination with luminary and positional differentiation, as the chromosomally equipotential cells in the periphery of the budding flower form *M/f* stamens and pollen and the central cells form the *F/m* pistil and ova.

In some unicellular organisms (Mastigophora) and some multicellular organisms (algae), both plant and animal types exist, indicating a common origin. Plant cells form chlorophyll, a protein-magnesium enzyme that has the power under adequate heat and light activation of anabolizing water and carbon dioxide molecules into highly complex sugar molecules, building up thereby molecular stores of potential kinetic energy. Sugars are worked over, principally at night under reduced heat and light, into fats and proteins and, with the aid of the bacterial solution of mineral acids and bases in water and soil, plants build these substances into mineralized proteins and more or less stable cell structures.

Most of the stores of energy in plants are used in reproductivity and as food against catabolic reduction. Little are used for catabolic release of energy in motion in reaction to stimulation. Plant cells generally have rela-

---

[1]It is well known that hormone administration has bisexually reconstituting or reversing effects in man and other animals. Reversing growth effects have been demonstrated in embryos, but such evidence need not be presented here.

tively hard, lifeless outer shells of low elasticity, and their mobile forms have only slow, slight sensitivity and motility and very low heat production.

Animal cells have an elastic, living ectoplasmic casing and greater sensitivity and motility than plants. They contain protein-iron or protein-copper (hemin) compounds which are indispensable for oxidation and reduction of sugar and other molecular stores of energy. In their catabolic actions animal cells break down the sugar molecule, obtained from plants, through oxidation into water and carbon dioxide molecules, liberating thereby kinetic energy in the form of organized molecular movements characteristic of cell sensory and motor reactions and the unorganized intra- and intermolecular motions of heat.

The bidynamic differentiation of plants moved towards stronger anabolism and weaker catabolism, and animals moved towards dependent anabolism and stronger catabolism. Herbivora generally have greater anabolic powers and weaker catabolic powers than Carnivora in that they can assimilate and metabolize lower plant foods whereas Carnivora are dependent upon Herbivora for more highly synthesized animal foods. Plant and animal interdependencies are illustrated by animal cultures (ants, man) of plants for food, shelter and heat, and plant uses of animal excreta and dead tissues for building plant cells. A close symbiotic interaction exists in plant respiratory elimination of oxygen and consumption of carbon dioxide and animal respiratory elimination of carbon dioxide and consumption of oxygen. The importance of such interdependencies is particularly evident for plant and animal life in stagnant pools. It is here almost as close as the interdependence of internal cells in plants and animals upon carrier cells of respiratory gases for assimilation and elimination.

The ratio of use of energy for reproduction and other growth, or for work, is the basis for the bidynamic evolution of animals from plants and the principal factor in further morphological and physiological qualitative and quantitative differentiations. The importance of relativity of use of anabolic resources for reproduction or for work becomes evident in the greater rate of anabolism over catabolism in plants and their almost unlimited reproductivity compared to animals. In the latter, Protozoa generally have higher reproductive rates than low Metazoa, and invertebrates generally have lower catabolic rates than vertebrates and higher reproductivity. The evolution of vertebrates shows a similar ratio of decreasing reproductivity with increasing catabolism. Increasing use of energy for autogenous regulation of heat production against exothermal reversals and sterilizations becomes a factor of increasing importance in the evolution of reproduction.

The thermogenic organs are used for work and as excitors of mating for reproductive selection. Oviparous, poikilothermic, externally incubating fishes, amphibians, and reptiles are directly dependent on solar heat and are seasonally highly reproductive. Ovoviviparous reptiles and fishes have a lower reproductivity than oviparous. Reproductivity is still lower in incubating reptiles with a body temperature up to 8° C., and in incubating birds with a very high catabolic rate and body temperature. Carnivorous birds are generally less reproductive than omnivorous. In placentals reproductivity generally decreases as thermogenesis and other catabolism increases, and this rule applies also within the species as individuals use more energy in work to live and get food. Metazoan parasites generally increase in reproductivity the less they have to work for food. Here regressive evolution is common as the host supplies easy and adequate nutrition and means of migration. The ratio of energy used in reproductivity and work is also of great importance in the evolution of man and his social organization.

The law of conservation of energy determines that the ratio of energy used in work for survival is relative to the energy used in reproduction, and this ratio, probably more than any other factor, determines the course and extent of progressive or regressive evolution.

(*a*) *As less energy is used in work more energy tends to be used in reproductivity, and evolution tends to be more varied but somatically weaker or regressive in powers of self-determination.*

(*b*) *As more energy is used in work less is used in reproductivity, and evolution tends to be restricted but stronger or progressive in self-regulating powers.*

(*c*) *As the use of energy in work becomes excessive, then reproductivity becomes minimal and evolution becomes stationary or life ends.*

The large number of closely related fossils in some geological periods and the small number of distantly related fossils in others have been interpreted as evidence of epochal genic mutations. The theory of the ratio of use of energy for work or reproduction in supporting and opposing environments offers a pragmatic explanation of evolution.

As supporting environments (SEn) decrease use of energy in work (ew) they increase energy for reproductivity (ER), resulting in greater populations (GP) and greater variations (GV) and greater range of reproductive selection (GR), hence greater diversity of evolution producing a greater number of closely related species (GEv). Hence fossils are increased in number and variety with close relations. The evolution of life in supporting environments may be equated as follows:

$$SEn + \frac{ER}{ew} = GP + GV + GR + GEv$$

Supporting environments with sharp, severe limitations, as in the hosts of parasites, tend to evolve high reproductivity with regressive somatic organs.

As opposing environments (OEn) compel increase in the use of energy in work (EW) they reduce energy for reproduction (er), tending to survival of lesser populations (LP) with lesser number of variations (LV) and a lesser range of reproductive selection (LR), hence less diversity of evolution and fewer closely related species (LEv). Hence fossils are reduced in number and variety, with distant relations.

$$OEn + \frac{EW}{er} = LP + LV + LR + LEv$$

Very severe, long continued environments generally reduce reproductivity to *fixed* types and stop evolution. Further environmental stresses lead to extinction.

Long periods of easy environments, alternating with short periods of severe environments with isolating climatic differences in heat, light and humidity, produce great variations in great numbers followed by severe eliminations of all but a small number of varieties, resulting in small, isolated populations distantly related. Thus *alternating extremes in supporting and opposing environments are most conducive to diverse and progressive evolution towards more economical and extensive self-determination.*

The origin and evolution of new, more specialized organs from more generalized organs has been held to be outside of natural selection, hence the result of mutations. My theory holds that the autogenous pressure of energy of life is towards maintaining internal with external equilibration in the mating and reproductive direction against all internal and external imbalancing conditions. Hence the tendency is to develop ontogenetically and repeat phylogenetically, in a sequence of small steps, special organs from more general organs as internal or external conditions become specifically and continuously stressing upon one part of the organism in ways that involve all of the other organs as a holistic unity. The same orderly emergence in all triploblasts of special tissues from primal tissues shows abundantly that pragmatic autogenous direction of evolution dominates the accidental mutational direction. Organisms function more efficiently in special ways and in special environments as they have special mechanistic organs, and these organs are more or less modified as they are forced to use them in new ways. Haeckel's law that *ontogeny recapitulates phylogeny* with minor partial to holistic modifications should be supplemented with the law that *phylogeny follows ontogeny* in its deeper holistic modifications.

The origin and evolution of thermo-bidynamic bisexual differentiation is evidently consistent with the origin and evolution of other organismic differentiations to quantitative and qualitative variations in environmental activations and nutritions, including the effect of heat, light, and humidity on pituitary and other endocrine secretions directing the adaptation of estrus and gestation for parturition in favorable climatic conditions.

Life's Autogenous Leverage of Its Evolution Through Reproductive Selection

The autogenous processes of life, that have determined the evolution of bisexual differentiation from protozoan and metazoan bisexually equipotential, simultaneously or alternately matured, exothermally differentiated, autothermogenically indifferent, externally self- to cross-fertilizating hermaphrodism—to metazoan bifertile but unilaterally matured, exothermally differentiated, autothermogenically weak and inconstant, internally fertilizing, and partial to complete incubating heterosexualism—to irreversibly unifertile, autothermogenically constant, placental and mammary feeding heterosexualism, demonstrate *progressive economies in the use of energy for increasing self-determination against opposing external forces through reproductive selection.* That certain kinds of organismic mechanisms, in millions of generations of millions of adults and gametes, in certain environmental supporting and opposing conditions stepped further in this direction than others constitutes the major phenomenon in the evolution of life with its environment.

Each species is chemically continuously although adaptively self-consuming, and digests and metabolizes as needed for repetitiously reconstructing its states of internal with external equilibration only special kinds of fats, carbohydrates, proteins and other substances produced in other particular species. Each species must therefore, by the law of conservation of energy, be mechanistically so specialized in its receptors and somatic projicient organs that it can capture more of such energies within particular environmental limitations than is needed to compensate for such work, growth, escape from destructive conditions, healing of injuries and diseases, living, mating, and reproduction. The economical use of energy in growth and work is as important for survival and reproduction as capturing energy. The somatic organs used in work to live are also used in mating (finding mates, defeating rivals, and in exciting and being excited). Hence their mechanical form, color, strength, and fitness largely determine success in both fields. The morphological and physiological differentiation in the sex primary gonads,

secondary gonoducts, tertiary somatic organs, and quaternary personality attitudes determine selection between male and female adults as means for gametic competition and fertilization. Hence there must be a concomitant and coöperative evolution in sex and somatic organs and gametes and zygotes; and their basic phylogenetic patterns, in limiting environmental conditions, determine the directions of ontogeny and further evolution.

As climatic conditions are equilibrating populations in plants and animals expand, using each other as foods in ecological cycles. Natural selection is then less severe, and wider, less economical somatic variations in equal sex ratios are generally able to survive in bisexually equipotential or bisexually reversibly differentiated, thermally inconstant animals. Then greater ease of mating and reproductivity within a greater range of sex and somatic variation results. In Protozoa, and smaller, more simple Metazoa, repeated reproductions within the year generally equalize in sex ratios as seasonal fluctuations of climate generally balance up the annual heat, light, and humidity ratios.

When climatic conditions are excessive or deficient in heat, more than any other factor, populations of annually breeding equipotential Metazoa are reduced with unequal sex ratios ($M/f > F/m$ in excessive heat and $F/m > M/f$ in deficient heat). Then competition becomes proportionately severe and selective between M/f adults and gametes and F/m adults and gametes for the most attractively excitatory mates, with more completions among the better equipped, vigorous and competitive phenotypes and more fertilities among the more complementary genotypes, hence eliminations of the less fit. Reproductive selection is, thereby, generally, repetitiously converged upon the phenotypic and genotypic continuation and accumulation of better autogenous capacities for completing the physico-chemical equilibrations of mating and reproduction as with other needs. This trend is gradually extended, within the pattern of hereditary morphological and physiological mechanisms in limiting environmental ranges, towards greater autothermogenesis with other working powers. Each advantage gained in self-determination with ability for social cooperation becomes the foundation within such limitations for the evolution of higher forms. Naturally, only special organismic mechanisms in special environments could advance from hermaphrodism to heterosexualism and from aquatic to terrestrial living, from poikilothermy to isothermy, from oviparity to ovoviviparity to viviparity. Taxonomic evidence correlated with environmental evidence abundantly demonstrates this principle. These processes explain how many different interdependent plant and animal mechanisms can live in a relatively

constant environment like a stagnant tropical pool, and how a generally adaptable species, like the rat, can live in great environmental ranges and become more or less differentiated as environmental isolations differ, leading to overspecializations like the kangaroo rat in a narrow habitat.

The continuity of *reproductive selection* has a very narrow range within *sexual selection* (which includes sterile and lethal matings and unreproductive offspring) which exists within the wider range of *natural selection* (which includes environmental support for survival of fit gametes, embryos and adults and elimination of the unfit). *The individual works primarily for self-preservation and secondarily for reproduction but the two processes are inseparable and the direction of evolution is based on reproductive selection within the limitations of natural selection.* The latter does not in itself account for the evolution of the reproductive organs and thermogenesis. Reproductive selection, however, among those survivors of natural selection who are most resistant to and self-determinative against environmental heat, light, and humidity variations and sexually best competitive and coöperative, accounts for the evolution of sex chromosomes and organs concomitantly with somatic chromosomes and organs.

Antlers of the deer family are male sex linked deciduous organs that mature as weapons for sexual competition and then are lost in winter when they might be defensive against enemies as in the antelope family. Organs advantageous in reproductive selection *evolve progressively* even though they become uneconomical impediments in the work to live, like the massive antlers of the Irish elk or the cumbersome tail of the peafowl. Organs advantageous under natural selection but disadvantageous in reproductive selection *evolve regressively,* such as hairiness and powerful bodies in women in favor of smooth skin and petite delicacy. Genotypes carrying mutations that are advantageous in natural selection but disadvantageous (lethal or sterile or inhibitory) in reproductive selection are eventually self-eliminating. Mutations advantageous in reproductive selection tend to survive although disadvantageous in natural selection.

In vascular Metazoa the somatic differentiation forms a cytoplasmic side chain which builds up the organismic nurse and carrier of germ cells and distributor of gametes, which later may also become the carrier and nurse of the embryo. This direction of organization evolved into the highly individualized organism and specialized person of temporary duration whose chief social work in life is the development of itself for, directly and indirectly, promoting reproduction. This contrasts with the cyclical cytoplasmic continuity of direct reproductions existing in germ cells and gametes through

zygotic union to early embryonic germ cells to mature germ cells to gametes.

The blood stream is adapted to carry a basic ratio of anabolic and catabolic hormones and other substances between all of the cells of the organism. It is kept in a state of near constancy or counterbalancing adjustment to the ratio of consumption by adaptive rates of work of different organs of cells, and the ratio of digestive assimilation, storage and secretion, and renal, pulmonary and other excretion, and thermal, luminary and other activations. The hemodynamic ratio is thereby more or less adaptable to ratios of environmental excitatory and inhibitory conditions, work, nutrition, diseases, etc. It has been previously shown that since like chromosomal-genic organizations are inherited by all cells of the organism they must reproduce themselves qualitatively, quantitatively, and positionally and reproduce specific cytoplasmic qualities in the different tissues while the quantitative ratios of the latter qualities are regulated by the rates of flow of special substrates through special kinds of stimulation, work, nutrition, and elimination.

Abundant, well known experimental and clinical evidence, some of which has been previously cited, on the effects of heat, vitamins, hormones, minerals, toxins and organismic positions on somatic differentiation and development and on embryonic gonads and the growth, viability and reproductivity of germ cells and gametes, leads to a definite conclusion. *No chromosomal or cytoplasmic barrier exists in germ or other cells to acquiring quantitative modifications of special cytoplasmic qualities by long continued changes in ratios of special metabolites in the blood.*

The hemodynamic ratio and the ratio of different kinds of endocrine and nervous activation by climatic conditions, supplemented by light and other physical and social stimulation, are the principle means of placing, timing, qualifying, and quantifying the differentiation and organization of growth of organs so that gonads and germ cells are reproductive in the mature period of the organism and in advantageous seasons with right mating interactions.

The ratios of metabolites in the cytoplasmic organization of the egg, and probably sperm, transmitted from the parent, have been experimentally found to influence the effects of chromosomal determination of the ratios of the diploblastic or triploblastic development of the gastrula (hence the ratios of special embryonic tissues in the formation of special organs). We may therefore conclude that *no complete barrier exists within the range of chromosomal limitations to the hereditary transmission of acquired modifications in hydynamic ratios in germ cell cytoplasm, and their quantification of the qualitative effects of chromosomal determination.*

The experimental demonstrations of a great increase of mutations in Drosophila by increase of heat, and of bisexual cytoplasmic differentiation counter to the chromosomal determination in amphibians, indicate that *special cytoplasmic ratios have special kinetic potentials which condition the more direct effects of heat on the more constant chromosomal-genic pattern, tending to change genic and chromosomal reproductions quantitatively and then qualitatively.* Chromosomal polyploidy and translocations in meiotic reorganization possibly occur in some such manner.

The "germ plasm" has been dogmatically held since Weismann (44), on the unconvincing and very incomplete evidence of special amputations and habituations, to differ in some essential way from "somatic plasm" and to be immune from acquiring modifications by somatic functions as suggested by Lamarck (29). Weismannism erroneously claimed that the repetitious, excessive use of a special organ or an acquired special immunity for a number of generations should lead to its hereditary progressive development, and repeated eliminations or disuse should lead to its regression, if the inheritance of acquired characters is true. This interpretation of the negative results neglected the organism's innumerable compensatory counterbalancing regenerative powers, and its resistant powers to the modifying effects of eliminations, and considered the specific organ instead of the whole organism. It neglected changes in ratios of special metabolites in the blood stream over long periods during incompletely differentiated and determined embryonic growth and gonad formation.

If the chromosomal organization of genic factors were to determine quantitatively as well as qualitatively the energic ratios of the cytoplasm (somatoplasm and germ plasm) as many geneticists still assume, rigid, unadaptable cell mechanisms would develop in each generation, whatever the genotype, since all cells in the organism inherit like chromosomes. The chromosomes would reproduce only special types of uniform unicellular organisms or masses of cells of one type, as in tumor growth or tissue cultures. This, now prevailing, theory fails to explain logically how chromosomes can in themselves differentiate the cytoplasm quantitatively as well as qualitatively for the different kinds of cells in embryonic development so as to produce special organs that fit economically in qualitatively and quantitatively differentiated, intercellular and extracellular environmental positions and conditions. If biology rejects *environmental quantification of chromosomal qualifications of cytoplasm* it must assume the magic of accidental or intelligent chromosomal determination in ontogeny as it has in phylogeny. The experimental evidence on embryological transplantations

and eliminations so completely supports the theory of environmental quantification of chromosomal cytoplasmic qualification that complete hereditary predetermination is no longer tenable.

If there were no hereditary, highly stabilized and consistent chromosomal regulations of cytoplasmic qualities, then life would be too highly variable to form harmoniously organized tissues in organisms. Then orderly continuity of evolution or development would not exist. Hereditary chromosomal qualitative, and environmental acquired quantitative determination of the cytoplasm, leading to hereditary quantitative determination of germ cell cytoplasm, enables each generation of cells through increase of more used properties and decrease of less used properties, to adapt itself economically to its special intercellular and extracellular environmental conditions and form and differentiate organs, including the gonads, to fit into the special bioelectric fields of the organism as a whole, with somewhat adaptable ontogeny that is consistent with its phylogeny.

Conclusions

A new explanation of the origin and evolution of bisexual reproductive, and somatic differentiation through thermal differentiations of the ratios of anabolic to catabolic action in cells and organisms as a whole has been offered which is consistent with chromosomal-genic and hormonal determinations.

Heat above the equilibratory level for the special chemical constitution of M/F equipotential gonads accelerates catabolism faster than anabolism, with M/f differentiations, and heat below this level decelerates catabolism faster than anabolism, with F/M differentiations, in unicellular and multicellular organisms.

As chromosomal-genic bisexual differentiation gradually increased in evolution from amphibians to reptiles to birds, and reptiles to mammals, the gonadal bisexual differentiation grew more decisive in the differentiation of the germ and soma cells, and the organs and organism as a whole, when supported by adequate thermogenesis.

The genotype is normally constant for the organism and qualitatively limits the development of the phenotype, but it is naturally directly affected by heat and other energic radiations and indirectly affected by these and additional factors which change the quantitative ratios of special qualities of ions and substrates in the cytoplasm. These conditions may affect the quantitative reproductions of genes in mitosis and their qualitative chromosomal locations during crossings in meiosis of germ cells. Certain kinds of cytoplasmic chemical ratios seem to be inheritable. Evolution is therefore

the product of the natural selection of the fittest to survive under limiting environmental conditions, limited further by the autogenous sexual selection of mates in adults, limited further by the autogenous reproductive selection of the fittest gametes.

A new explanation of the differentiation and development of the organism has been offered in lieu of the unsatisfactoriness of previous theories which attributed magical powers of timing, placing and grading differentiation, to like complements of chromosomes and genes in all cells of the organism.

Chromosomal-genic regulation of qualitative cytoplasmic reproductions, and environmental regulation of the quantitative ratios of these qualities, explain the differentiation and development of germ cells and all the tissues of the organism and their acquired cytoplasmic modifications. Cytoplasmic modification of genes and chromosomes, although slight, is a cumulative, pragmatic, economical means of autogenous adaptation, that accounts for the drive of self-determination in evolution as well as in individual development and does not base either entirely on chance. Autogenous pragmatic adaptation is the decisive drive in the individual development and the evolution of life. This accounts for the harmony in the morphology and physiology of somatic organs and reproductive organs and gametes with progressive bisexual differentiation and thermogenesis for greater control of reproduction.

A law of the hereditary and environmental adaptation of life can now be formulated. *Chromosomal genic organization determines the qualitative differentiations of the cytoplasm, and intercellular and extracellular environmental conditions determine the quantitative differentiations of these qualities.* This makes ontogeny and phylogeny consistent and continuous, although the latter is far more stable than the former, and explains developmental and evolutionary adaptation to new environmental conditions.

The evolution of bisexual, reproductive, and somatic differentiation is a progressive extension of self-determination of internal with external equilibration against internal and external disequilibration. Disease is the breakdown of physio-psychological and psycho-physiological mechanisms of self-determination.

Evolution is not solely the purposeless product of the accumulative organization of chance genic and chromosomal mutations through the limitations of natural selection as held since Weismann by many biologists. It is also the product of an autogenous drive of the bidynamic constitution of life for extension of unconscious and conscious self-determination in time and space for greater viability and reproductivity.

Every cell and every organ and the organism as a whole and all of their

functions at every integrative level are bisexually equal or more or less differentiated, chromosomally, hormonally, and stimulation conditionally.

Bisexual differentiation has its origin in the physico-chemical mechanisms of self-determination.

Bisexual differentiation in the chromosomal-genic organization determines the degree of bisexual differentiation of the gonads; and the ratio, quantity, and extent of gonadal hormonal secretions differentiate the growth of the bisexual gonoducts and external genitals and other somatic organs and their integrative organization of the personality.

The bisexual attitude is further differentiated in man and other cerebro-cortically dominant mammals by the conditioning bisexual social pressure of approvals and disapprovals towards masculine dominance or feminine submissiveness in mating behavior.

Bisexual differentiation may be consistent in all of these interactive levels of organized growth or more or less in conflict. The physician must find wherein such conflicts exist and correct them with surgical reconstructions in anomalous growths, with endocrine support in reversals or deficiencies and with psychotherapeutic analysis and suggestions and social readjustments of attitudinal psychopathology.

Violations of the integrity of autogenous determination and bisexual differentiation at the holistic psychosomatic level of organization produce disease. In man physical or chemical therapy or psychotherapeutic or social readjustment is successful only so far as it restores an easily functioning, socially coöperative and competitive, autogenous integrity with decisive bisexual differentiation of attitude consistent with the organismic differentiation.

References

1. Arey, L. B. Developmental Anatomy. (4th ed.) Philadelphia: Saunders, 1942.
2. Baitsell, G. A. A modern concept of the cell as a structural unit. In *Biological Symposia:* I. Lancaster: Cattell, 1940.
3. Bard, P. McLeod's Physiology in Modern Medicine. St. Louis: Mosby, 1941.
4. Bridges, C. B. Cytological and genetic basis of sex. In E. Allen (*Ed.*). *Sex and Internal Secretions.* (2nd Ed.) Baltimore: Williams & Wilkins, 1939.
5. Child, C. M. Cellular Differentiation and External Environment. Lancaster: American Association for the Advancement of Science, 1940.
6. Child, G. P. Temperature and differentiation of characters in Drosophila. In *Biological Symposia:* VI. Lancaster: Cattell, 1942.
7. Cowdry, E. V. Special Cytology. New York: Hoeber, 1932.
8. Danforth, C. H. Relation of genic and endocrine factors in sex. In E. Allen (*Ed.*). *Sex and Internal Secretions.* (2nd Ed.) Baltimore: Williams & Wilkins, 1939.
9. Dürken, B. Experimental Analysis of Development. New York: Norton, 1932.

10. DURYEE, W. R. Comparative effects of x-radiation on isolated and non-isolated nuclei. *Anat. Rec.*, 1939, 75, Sup. 144.

11. FANKHAUSER, G. Induction of polyploidy in animals by extremes of temperature. In *Biological Symposia:* VI. Lancaster: Cattell, 1942.

12. GIESE, A. C. Studies on conjugotion in Paramecium multimicronucleatum. In *Biological Symposia:* I. Lancaster: Cattell, 1940.

13. GOLDSCHMIDT, R. Physiological Genetics. New York: McGraw-Hill, 1938.

14. HARGITT, G. T. What is germ plasm? *Science,* 1944, **100**, 2599.

15. HEILBRUNN, L. V. An Outline of General Physiology. Philadelphia: Saunders, 1943.

16. HEILBRUNN, L. V., & MAZIA. In Duggar's *Biological Effects of Radiation.* New York: McGraw-Hill, 1926.

17. HOSKINS, R. Endocrinology. New York: Norton, 1941.

18. HOWELL, W. Physiology. Philadelphia: Saunders, 1939.

19. IVES, P. T. The effects of high temperature on bristle frequencies in scute and wild type males of Drosophila melangaster. *Genetics,* 1939, **24**, 3.

20. JENNINGS, H. S. Sex reaction types and their interrelations in Paramecium bursaria: I, II. *Proc. Nat. Acad. Sci.,* 1938, **24**.

21. ———. Paramecium bursaria: mating types and groups, mating behavior, self-sterility. Their development and inheritance. In *Biological Symposia:* I. Lancaster: Cattell, 1940.

22. ———. Hereditary status of the rhizopods. In M. Demerec (*Ed.*). *Cytology, Genetics and Evolution.* Philadelphia: Univ. Penna., 1941.

23. ———. The transition from the individual to the social level. In *Biological Symposia*: VIII. Lancaster: Cattell, 1942.

24. JOLLOS, V. *Arch. f. Protistenk.*, 1921, **42**, 1.

25. KEMPF, E. J. Phylogeny of thermo-bidynamic bisexual differentiation. *J. Clin. Psychopath. & Psychother.* 1945, **7**, 1.

26. ———. Ontogeny of bisexual differentiation in man. *J. Clin. Psychopath. & Psychother.,* 1945, 7, 2 and 3.

27. KIMBALL, R. F. Change of mating type during vegetative reproduction in Paramecium aurelia. *Genetics,* 1939, **24**.

28. KUDO, R. Protozoology. Springfield: Thomas, 1939.

29. LAMARCK, J. B. System des Animaux sans Vertebres, 1801.

30. MOORE, C. R. Biology of the testis. In E. Allen (*Ed.*). *Sex and Internal Secretions.* (2nd Ed.) Baltimore: Williams & Wilkins, 1939.

31. PINCUS, G. Superovulation in rabbits. *Anat. Rec.,* 1940, **77**, 1.

32. PLOUGH, H. H. Temperature and spontaneous mutation. In *Biological Symposia:* VI. Lancaster: Cattell 1942.

33. POPA, G. T. A contribution to the biology of spermatozoa. *Proc. Sec. Internat. Sex. Cong.*, 1931.

34. REYNOLDS, B. D. Interactions of protoplasmic masses in relation to the study of heredity and environment in Arcella polypora. *Biol. Bull.,* 1924, **46**, 106.

35. SCHOENHEIMER, R. The Dynamic State of Body Constituents. Cambridge: Harvard Univ. Press, 1942.

36. SHARP, L. W. Fundamentals of Cytology. New York: McGraw-Hill, 1943.

37. SHUMWAY, W. Introduction to Vertebrate Embryology. New York: Wiley, 1942.

38. SINNOTT, E. W., & DUNN, L. C. Principles of Genetics. (3rd Ed.) New York: McGraw-Hill, 1939.

39. SONNEBORN, T. M. Sex, sex inheritance and sex determination in Paramecium aurelia. *Proc. Nat. Acad. Sci.*, 1937, 23.

40. ———. Paramecium aurelia: mating types and groups. Lethal interactions, determination and inheritance. In *Biological Symposia:* I. Lancaster: Cattell 1940.

41. SPEMANN, H. Embryonic Development and Induction. New Haven: Yale Univ. Press, 1938.

42. TABULAE BIOLOGICAE, 3. Berlin, 1926.

43. THOMPSON, D. W. On Growth and Form. New York: Macmillan, 1944.

44. WEISMANN, A. The Germ-Plasm: a Theory of Heredity. Oxford: Oxford Univ. Press, 1893.

45. WILLIER, B. H. The embryonic development of sex. In E. Allen (*Ed.*). *Sex and Internal Secretions.* (2nd Ed.) Baltimore: Williams & Wilkins, 1939.

46. WILSON, E. B. The Cell in Development and Heredity. New York: Macmillan, 1940.

47. WITSCHI, E. Modifications of development of sex in lower vertebrates and in mammals. In E. Allen (*Ed.*). *Sex and Internal Secretions* (2nd Ed.) Baltimore: Williams & Wilkins, 1939.

48. WITSCHI, E. Temperature factors in the development of the evolution of sex. In *Biological Symposia:* VI. Lancaster: Cattell, 1942.

49. WOLF, W. Endocrinology in Modern Practice. Philadelphia: Saunders, 1940.

Wading River, Long Island
New York

SHORT ARTICLES AND NOTES

The Journal of Genetic Psychology, 1947, **71**, 137-142.

IS ATROPHY THROUGH DISUSE A CAUSE OF FORGETTING?

Central Michigan College of Education

OSCAR OPPENHEIMER

The aim of this paper is to show that atrophy through disuse is not a cause of forgetting. Important phenomena in the field of forgetting could not be understood if *a. t. d.* was a cause of forgetting, and *all* phenomena in the field can be interpreted in terms of interference as the only cause of forgetting. In other words: there is no *a. t. d.* in our field, *and* there is no need for it. For a description of the rôle which *a. t. d.* and interference are supposed to play I am selecting Woodworth's ideas on the subject:

> There are, in fact, two theories of forgetting.
>
> 1. Atrophy through disuse. Though mere inactivitiy of a structure, is not a force or cause that could do anything to the structure, the memory trace, like any biological structure, needs to be kept alive and well nourished. A muscle certainly loses strength and substance when it is inactive for a long time, as happens when a broken arm is kept in a splint. The inactive muscle loses out in the competition for nourishment that goes on all the time in the organism. When a muscle has just been active it is in a state that may be called "hungry." It sucks up nourishment from the blood. It does not do this during prolonged inactivity but, on the contrary, loses substance to the blood. So the muscle grows as the result of its activity and atrophies from disuse. There is no reason why delicate brain structures built up in learning should be exempt from this general biological law.
>
> 2. Interference. In waking life we are continually changing our activity. Every moment we do something different. If every act were controlled by its own small center in the brain, there would be no interference and no reason why the performance of one act should disturb the structure concerned in another act. But we know that the brain acts in wide-spreading patterns rather than in small, separate bits. The patterns used in different acts may overlap and coincide in part. Consequently there is a chance for interference. The brain pattern built up in learning one act may be disturbed by the subsequent performance of another act—especially, we may suppose, if the two acts are similar. The reasonableness of this theory can be brought home to us by trying to recall all the views we have seen during a trip through the mountains. One

*Received in the Editorial Office on April 7, 1946.

> view seems to wash out another, leaving only a few outstanding ones in memory .
>
> As the two factors of disuse and interference are probably both real, we cannot hope to decide between them.

The problem presented in the last sentence of Woodworth's statement is our problem. I hope to show that we can decide between the two factors. The reason, however, why I quoted Woodworth in full, is to point out his continual attempt to explain a purely mental fact such as forgetting by biological phenomena. This confusing of the two fields has contributed more to the establishment of the erroneous theory of forgetting than anything else, as we shall see soon.

But first let us discuss the phenomena which are opposed to an interpretation of forgetting in terms of *a. t. d.* There is the recognition and recall of experiences which happened long ago. This recognition and recall takes place if there is a stimulus strong enough to conjure them up in the mind: We return to the town of our childhood and see many things which we had completely forgotten. Seeing them and seeing many of them together makes us recognize them as part of our childhood experiences and makes us recall other experiences which were tied up with them in our childhood. Secondly, there are old age memories, when, at the age of 60 or 70, we suddenly remember things which were not in our conscious minds for 50 or 60 years. These memories differ from the first mentioned phenomena in two ways. There is no strong stimulus present to produce them, they just pop up, and furthermore, they are remembered clearly and in detail, while happenings of yesterday are forgotten. This last feature, along with the fact that they bridge so wide a gap, makes these memories particularly strong counter evidences to *a. t. d.* as a cause of forgetting. For here what should be freshest and, therefore, most easily remembered, is forgotten, and what should have shrunk out of our memory because of 50 years of disuse is remembered. Against our material it could be argued that while it disproves the theory for the scope of this material, it would not invalidate, of necessity, the truth of the theory for the rest of the field of memory. The one who argues this way overlooks two facts. First, if he was right, he could not explain how it comes that the theory works in the one case and not in the other. Secondly, interference is very able to account for all cases of forgetting. Both facts combined form a solid wall against the acceptance of the theory of *a. t. d.* If it is so that interference covers the whole field, and if, at the same time, certain phenomena are clearly opposed to an interpretation in terms of *a. t. d.*, why should we bother with a theory for which there is neither foundation nor need in the facts.

But having come so far we have not convinced the psychologist who believes in the memory trace in the brain as the basis of all memory, and as the thing that shrinks in the case of *a. t. d.* He cannot locate this memory trace in the brain, and consequently, he cannot observe how it shrinks, but he is sure of its existence on the general assumption, depending on his philosophy of psychology, either that there is a parallel in the brain to any mental act, or that a mental act is nothing but a brain process. Now, *a. t. d.*, as we can gather from Woodworth, is a well established theory in the biological field. We observe: the muscle shrinks unless it is used. The strength of the theory in the biological field, and the psychologist's conviction of the importance of biology for mental facts make him accept the theory in his own field in spite of the facts. Our case is a beautiful illustration for the saying, ascribed to Hegel: If the facts do not fit my theory, too bad for the facts! If we use, however, the opposite procedure and start with the facts and base the theory on them, then we will find the failure of the *a. t. d.* theory a neat evidence for the difference between biological and mental phenomena. We cannot get along without the theory in the biological field, and yet it is out of place in the mental field. This does not mean, of course, that I deny the close relationship between the fields, either so that they influence each other, or so that their phenomena run parallel. But I exclude the possibility of identity of the entire fields, and the need for identical phenomena in them.

One may be inclined to admit the strength of the argument against *a. t. d.*, and still doubt whether interference is a more recommendable explanation of forgetting. One may say: it is true that we accumulate a tremendous host of experiences, and that these experiences are different and opposed to each other as far as their content is concerned. But if we hold that any of them stay with us and influence our minds at any given moment with the result either of remembering or forgetting, are we not prompted to introduce the concept of the unconscious? Would not the unconscious have to be the place where our experiences are from the time they are received to the time they are remembered? Do we not accept a term which according to Woodworth (and many others) is "responsible for a good deal of mystification in psychology?" Do we have to follow him when he says: "There used to be much talk of the 'Unconscious' regarded as a separate part of the personality, but this way of talking has largely gone out of fashion"? Against Woodworth, we do not care whether the term has gone out of fashion. We need it, and we need it not just for the sake of explaining the single phenomenon of interference, but chiefly because there is no satisfactory understanding of the

whole field of memory without resorting to the unconscious. By definition it is the part of the mind of which we are not conscious, directly, but we are most conscious of phenomena which cannot be accounted for but by referring to the unconscious. When I remember a man whom I saw a week ago where was my experience of him during that week? So if I accept the existence of the unconscious in order to explain interference, I do not need to justify it here because it had to be assumed already before for the whole field in which interference is only a single phenomenon. Here it is interesting to notice the great difference between the theory of *a. t. d.* and the theory of the unconscious. The difference lies in their relations to the facts. Neither of them can be observed directly, but the one is conceived against and the other on the basis of facts.

Some may concede the existence of the unconscious and still feel that the theory of interference would force us to make too detailed a statement on the nature of the unconscious. They may say that we should beware of going further than assuming the existence of the unconscious because it is never consciously experienced. If this only means we should move slowly and cautiously because there is a definite danger of pure imagination, everyone agrees. On the other hand, we are allowed to go beyond the assumption of mere existence if the facts urge us to do so. For the facts are the judges. And, indeed, they urge us to go farther. In order to account for the field of memory in its entirety we must assume that all that we ever learnt is preserved in our unconscious minds. Nothing ever becomes lost because everything can be reproduced. This assertion is strengthened by the discard of the theory of *a. t. d.*, a theory which if true would have made space for gradual loss of part of what we learnt. But opponents will say, is it not fantastic to assume that all these tremendous piles of knowledge which we have acquired in the course of many years in a systematic and in an unsystematic way are preserved in the unconscious down to the last detail? And not only that, the assumption seems to become even more fantastic when we consider the diversity in this mass of material. How many different types of material, differing in so many ways, have we learnt! The principle reason why all this seems fantastic lies in our confusing the nature of the unconscious with the nature of the conscious. The conscious mind has only a narrow span, and we hold wrongly that the same must be true of the unconscious mind. We forget that there is no objection against the possibility that the unconscious mind may differ from the conscious mind in some features. We are allowed to assume such features if facts in the conscious mind require for their explanation such features of the unconscious mind.

Furthermore, the narrowness of the span of the conscious mind has as its cause a fact that we do not need find in the unconscious mind. In each act of thinking of the conscious mind, in the most simple as in the most intricate one, we concentrate on a few facts, the relations among which we examine, and it is a *conditio sine qua non* for successful thinking that we narrow down the span of consciousness to these few, and keep out others. There is nothing in the conscious part of the mind that would necessitate the assumption that we think in the unconscious part of the mind. Finally, the theory that we do not forget anything is not much more fantastic than the proven fact that we can *remember* an amazingly large amount of facts of very diversified nature. If we may assume that we have kept all of them in the unconscious mind—and we have—then the difference between this accomplishment of the mind and the accomplishment of forgetting nothing is as insignificant as the difference to a poor man's eyes between a rich man having ten millions and another having one hundred millions.

Yet this is not the greatest feat of the unconscious. We know that the rules of association are necessary, but not sufficient to account for recall and recognition. Not sufficient because too many different experiences were associated in the past with the present experience, and it is only one of them which we call up in connection with our present experience. Why do we call up the one and why not any other The conscious mind does not give any answer. It only records the fact. A partial explanation may lie in the temporal relation between our present experience and the various experiences with which it was connected in the recent past is recalled more easily than the earlier connections. To understand this, of course, we do not need to call in again *a. t. d.* The experiences do not need to shrink in the course of time in our unconscious. All that we need to say is that we have less interference for the recall of the more recent experience. This is plausible since we had less experiences from the time the later experience took place until now than from the time the earlier experiences happened. But even when we consider the importance of the temporal factor, we are prompted to see the different parts of the unconscious in a different state of readiness. Our experiences cannot fall into the unconscious and lie there in a pile in an utter disorder. Some kind of order must exist indicating their time of appearance in the unconscious. *How* this is done we do not know, *that* it is done the facts of conscious life force us to assume. And this order is even more elaborate than we have seen so far. Very often, we know, the rule of temporal association does not work because of other rules of association. I see a friend today whom I saw many times before, and the last time yesterday. Seeing him now does not make me recall the situation of yesterday but a

situation 30 years ago when I played with him in a sandpile. Just this morning I played with my little girl in a sandpile, and while this fact is not in my conscious mind, it is instrumental in reproducing the situation 30 years ago. In this illustration the temporal relation plays a certain rôle. Playing with my little girl happened only a short time ago, and that may be the reason why this experience comes in. But the rôle of the temporal relation is only a minor one. For what I remember is not the recent event, but an event long ago. The major rôle is played by a factor which is not only different from, but hostile to the rule that the more recent event is remembered first. What must have taken place in the unconscious in order to revive the earlier experience is a rather intricate process. In my unconscious the recent event of playing with my girl must have influenced the earlier event, else the recollection of the latter cannot be accounted for, neither my failure to recall an event instead that has been more recent. Besides, there must be a relation between the present conscious sensation of seeing my friend and those two unconscious experiences of the past, and this relation must exist in my unconscious because consciously I know nothing about it. Again, of what nature this relation is, whether the unconscious phenomena try to appeal to the conscious phenomenon, or whether the latter, more actively, selects one of the former, we do not know. The only thing we are certain of is that some kind of a relation must exist. Let us look at another case of recall. I see my friend and I remember a very sad happening long ago of which both of us were a part. Why among all the many recollections I could have of my friend does just this one come to me? It comes because the whole day up to this moment I have been in a sad mood. Analyzing my recall afterwards I realize that here not the concurrence of the past events in my unconscious mind make up the main history of the recall, but the relation between the conscious facts on the one hand, and the unconscious past event on the other hand make the recall of this past event possible. This case is even more interesting than the other one we discussed because a larger part of the conscious is involved in the unconscious process.

The discussion of atrophy through disuse has led us far into the discussion of other mental phenomena. But this is as it should be considering the intimate relations among mental phenomena.

Reference

1. Woodworth, R. S. Psychology. New York: Holt, 1940.

Central Michigan College of Education
Mount Pleasant, Michigan

The Journal of Genetic Psychology, 1947, **71**, 143-152.

BOOKS

The *Journal of Genetic Psychology*, the *Journal of General Psychology*, and the *Journal of Social Psychology*, will buy competent reviews at not less than $2 per printed page and not more than $3 per printed page, but not more than $15.00 for a single review.

Conditions. Only those books that are listed below in this section are eligible for such reviews. In general, any book so listed contains one or more of the following traits: (*a*) Makes an important theoretical contribution; (*b*) consists largely of original experimental research; (*c*) has a creative or revolutionary influence in some special field or the entire field of psychology; (*d*) presents important techniques.

The books are listed approximately in order of receipt, and cover a period of not more than three years. A reviewer must possess the Ph.D. degree or its equal in training and experience.

Procedure. If among the books listed below there is one that seems important to you, you are invited to write a review of that book. It is not necessary to make arrangements with the Editor. Just send in your review. It does not matter if the book in question has been reviewed before.

(1945)

MURPHY, G., *Ed.* Human Nature and Enduring Peace. New York: Houghton Mifflin, 1945. Pp. 475.

FREUD, A., *et al.* (*Editors*). The Psychoanalytic Study of the Child. (An annual, Vol. 1.) New York: International, 1945. Pp. 423.

FLÜGEL, J. C. Man, Morals, and Society. New York: International, 1945. Pp. 328.

RAPAPORT, D. Diagnostic Psychological Testing. (2 vols.) Chicago: Yearbook 1945. Pp. 573 & 516.

WERTHEIMER, M. Productive Thinking. New York: Harper, 1945. Pp. 224.

LEWIS, N. D. C., & PACELLA, B. L. Modern Trends in Child Psychiatry. New York: International, 1945. Pp. 341.

(1946)

HARRIMAN, P. L., *Ed.* Twentieth Century Psychology. New York: Philosophical Library, 1946. Pp. 712.

MASSERMAN, J. H. Principles of Dynamic Psychiatry. Philadelphia: Saunders, 1946. Pp. 322.

SEWARD, G. H. Sex and the Social Order. New York: McGraw-Hill, 1946. Pp. 301.

SMITH, B. L., LASSWELL, H. D., & CASEY, R. D. Propaganda, Communication, and Public Opinion. Princeton: Princeton Univ. Press, 1946. Pp. 435.

MORENO, J. L. Psychodrama. New York: Beacon House, 1946. Pp. 429.

SYMONDS, P. M. The Dynamics of Human Adjustment. New York: Appleton, Century, 1946. Pp. 666.

HARRIMAN, P. L. Encyclopedia of Psychology. New York: Philosophical Library, 1946. Pp. 897.

GESELL, A., & ILG, F. L. The Child from Five to Ten. New York: Harper, 1946. Pp. 475.

GESELL, A. The Embryology of Behavior. New York: Harper, 1946. Pp. 289.

DUNLAP, K. Personal Adjustment. New York: McGraw-Hill, 1946. Pp. 446.

DUNLAP, K. Religion: Its Functions in Human Life. New York: McGraw-Hill, 1946. Pp. 362.

RICHARDS, T. W. Modern Clinical Psychology. New York: McGraw-Hill, 1946. Pp. 331.

WOLFF, W. The Personality of the Preschool Child. New York: Grune & Stratton, 1946. Pp. 341.

FREUD, A. The Ego and the Mechanisms of Defense. New York: Internat. Univ. Press, 1946. Pp. 196.

BLAU, A. The Master Hand. New York: Amer. Orthopsychiat. Assoc., 1946. Pp. 206.

CATTELL, R. B. Description and Measurement of Personality. Yonkers: World Book, 1946. Pp. 602.

(1947)

SHERIF, M., & CANTRIL, H. The Psychology of Ego-Involvements. New York: Wiley, 1947. Pp. 525.

FLUGEL, J. C. Men and Their Motives. New York: International, 1947. Pp. 289.

ALLPORT, G. W., & POSTMAN, L. The Psychology of Rumor. New York: Holt, 1947. Pp. 247.

FREUD, A., *et al.* (*Editors*). The Psychoanalytic Study of the Child, Vol. II. New York: International, 1947. Pp. 424.

THURSTONE, L. L. Multiple-Factor Analysis. Chicago: Univ. Chicago Press, 1947. Pp. 535.

ALSCHULER, R. H., & HATTWICK, B. W. Painting and Personality: A Study of Young Children. Chicago: Univ. Chicago Press, 1947. Pp. (2 vols.) 590.

VARIOUS AUTHORS. Army Air Forces Aviation Psychology Program Research Reports. (Many volumes by various authors. A review may concern only one significant volume, or may involve the entire series.) Washington: U. S. Printing Office, 1947.

MURPHY, G. Personality. New York: Harper, 1947. Pp. 999.

ADRIAN, E. D. The Physical Background of Perception. Oxford: Clarendon Press, 1947. Pp. 95.

SNYDER, W. U. Casebook of Non-Directive Counseling. Boston: Houghton Mifflin, 1947. Pp. 339.

AXLINE, V. M. Play Therapy. Boston: Houghton Mifflin, 1947. Pp. 379.

CRITICAL REVIEWS OF RECENT BOOKS

The Journal of Genetic Psychology, 1947, 71, 145-150.

(Symonds, P. M. The Dynamics of Human Adjustment. New York: A. Appleton-Century, 1946.)

Reviewed by Albert Ellis

The Dynamics of Human Adjustment is one book that thoroughly lives up to its title. How, Professor Symonds asks at the outset, does the human individual—the whole human individual—adjust to situations, both outer and inner, that he confronts? And, in the ensuing 580 pages, he proceeds to give as precise, as detailed, and as consistent an answer to this question as one may expect to find in any contemporary psychological text.

Specifically, *The Dynamics of Human Adjustment* is concerned with the psychological mechanisms, as originally formulated by Freud and his followers, and as recently studied by many non-psychoanalytic investigators. Dr. Symonds examines the major mechanisms in detail, devoting a solidly filled chapter to each. Thus, his main chapter headings include: Adjustment; Drives; Frustration; Aggression; Punishment; Anxiety, Defenses Against Anxiety; Fixation; Regression; Repression and the Unconscious; Displacement; Introjection and the Superego; Projection; Identification; Conflict; Guilt and Self-Punishment; Sublimation; Reaction Formation—Reversal Formation; Compensation; Rationalization; and Miscellaneous Mechanisms. Then, for good measure, he has chapters on Fantasy; Love and Self-Love; and Normality.

The thoroughness with which Dr. Symonds approaches the mechanisms in general is mirrored in his individual analyses. Subsumed under the chapter heading devoted to each mechanism are (*a*) a definition of the mechanism; (*b*) its origin; (*c*) fundamental considerations relating to it; (*d*) the situations which call it forth; (*e*) its characteristic forms of expression; (*f*) its advantages and disadvantages; (*g*) its pathological implications; (*h*) its educational implications; and (*i*) therapeutic implications. And, to back up the theoretical discussions, are many interpolated, and down-to-earth, brief case histories. Obviously, this is no slip-shod presentation!

Dr. Symonds' work is, on many counts, an important and valuable contribution. It is just about the most complete discussion of the psychological mechanisms that has yet appeared in print. It is psychoanalytically oriented

in an unusually open-minded way that, on the one hand, encompasses the findings of virtually all the existing schools of analytic thought and, on the other hand, leans heavily upon scores of recent non-analytic psychological studies. It takes many of the less palatable psychoanalytic theories, including the old standbys of the Oedipus complex and anal eroticism, and brings them down to a hardheaded, practically commonsense, level where they become positively believable. It concentrates on normal rather than pathological manifestations; and every once in a while even resorts to what might be called normal, non-pathological language—that of the man in the street.

Among other welcome aspects of *The Dynamics of Human Behavior* are its emphasis on the practical implications of dynamic psychology; its pointing out the advantages of negative mechanisms like repression and aggression; its continual going below the surface of things, and the pressing still a shade deeper; its consistent anti-puritanism; its stressing of positive values, like flexibility, emotional release, and love; and its incisively annotated bibliography of 883 items.

The limitations of *The Dynamics of Human Adjustment* are largely those indigenous to most present-day writing that is psychoanalytically oriented. Precisely because Dr. Symonds has made such a scholarly synthesis of psychoanalytic theories of human adjustment has he failed to avoid some of the pitfalls which seem to be almost inevitably associated with current analytic formulations. Some of these pitfalls will now be discussed in detail, not to emphasize the weaknesses of Dr. Symonds' text—since he displays less of them than most analytic writers—but to bring out the point that even so *good* a book may still suffer from the failure of the psychoanalytic interpreters to meet some of the basic requisites of scientific writing.

1. *Over-generalization and exaggerated universalization.* On page 376, in reviewing the methods used to reduce guilt, Dr. Symonds correctly speaks of the somatic methods—like vomiting or defecation—*occasionally* (italics mine) used for this purpose. But on the same page he writes: "Obendorf makes the point that kidding *usually* (italics mine) represents criticism directed, of course, toward another person, but also represents something to which the kidder himself is sensitive and hence is an expression of guilt. Likewise, scorn and criticism of others, however mild and veiled it may be, represents the same tendency." Now, that all of us *occasionally* make fun of others because we are guilty about possessing the traits we are bantering them for having, is probably true; but that our banter *usually* results from such self-sensitivity and guilt is very doubtful. Similarly, Dr. Symonds writes (page 479): "There are many testing acts, such as trying the door

to see if it is locked, testing one's watch to make sure it has been wound, looking under the bed to make sure there is no intruder, turning back to make sure one has turned out the lights, whose function it is to undo some prior act. . . . In this testing form of undoing there is *always* (italics mine) implicit the presence of an unconscious desire which is to be undone by the testing act." *Always?* Is this—to say the least—not a little far-fetched?

This kind of over-generalization from analytic findings probably stems from the fact that, to date, analysts have almost exclusively dealt with serious neurotics. That such individuals, when they banter their friends, or test their watch to make sure it is wound, frequently, even usually, are motivated by unconscious guilt or restitution feelings may possibly be true; but that normal, non-neurotic individuals are thus *usually* motivated, seems unlikely.

2. *Anthropomorphism.* On page 140, Dr. Symonds presents the view that "anxiety puts in its first appearance at birth and is evidenced by the infant's spasmodic efforts to catch its breath and to utter its first wail." And, in his chapter on Love and Self-Love, he is equally positive that "love finds its origin at the start of life in the infant's experience of pleasure. An infant's first expressions of love are erotic, as he finds pleasure in the stimulation of certain sensitive bodily zones" (p. 522). Now perhaps normal *adults* become anxious when they have to make spasmodic efforts to catch their breath, and begin to love others who bring them erotic pleasure, but to impute such feelings to neonates is to wade in dangerous quicksand. Maybe one-day-olds *are* anxious and *do* love; but what makes the analytic writers so *sure* of this? Where are the supportive factual data?

3. *Over-patternization of attitudinal development.* Following orthodox psychoanalytic concepts, Dr. Symonds states (p. 413): "At the time of the Oedipus complex which comes when boys are around the ages of 4 and 5, there are marked erotic feelings toward the mother. Later, however, these are suppressed, and in their place one finds tender feelings later recognized as sentiment." The inferences of these two sentences are: (1) that *all* boys have an Oedipus complex; (2) that they *all* obtain it between the fourth and fifth year; (3) that later they *all* suppress their erotic feelings toward the mother; and (4) that they *all* displace them to tender feelings. These assumptions do violence to the concept of individual differences in heredity and environment which is one of the cornerstones of modern psychological thinking. If—as is certainly the case—even physiological maturation is far from an orderly and inevitable progression, it seems most unlikely that attitudinal development is half as rigid and neat-niched as the analytic writers

would usually have us believe. Even assuming that the Oedipus complex is a generalized human occurrence—an assumption which has by no means as yet been indubitably proven—it must be assumed that, out of 100 randomly sampled boys, some will experience it before and some after their fourth or fifth years; some will later suppress their erotic feelings toward the mother and some will not; and of those suppressing their feelings, some will sublimate them into tender sentiments, while some will sublimate them into aggressive, self-punitive, anxious, or other feelings. Thus, of the original 100 randomly selected boys, only a fraction, and probably a small one, will follow the classical Freudian line of Oedipal development. Yet, the impression is frequently given by psychoanalytically oriented writers that, first, *all* boys develop along Oedipal lines; and, second, that their developments follow almost identical curves.

4. *All-inclusiveness and one-sidedness.* Dr. Symonds, unlike many other psychoanalytic writers, does *not* make the mistake of explaining all human behavior in terms solely of psychological mechanisms and dynamisms. He takes good care, at times, to mention the rôle of physiological drives, environmental influences, education, and even self-determination, in motivating human behavior. Still, his emphasis, or that of those he quotes with approval, is sometimes one-sided. Thus, he states (p. 413) that "a widespread observance of Mother's Day is testimony to this sublimation [of the Oedipus complex into tender sentiments]." Perhaps so;—but the nationwide propaganda of the florists, candy-makers, and other business interests has certainly had *something* to do with this observance. Again, while Dr. Symonds' chapter on Love and Self-Love contains many pages about infantile love, anaclitic love, and narcissistic love, it barely mentions the common garden varieties of courtship love and marital love into which, as yet, the neurotic-oriented analysts have yet to sink their scalpels very deeply. What the psychoanalysts have found is most important; but it is hardly all-inclusive. What remains to be found, by both analytic and non-analytic researchers, is still immense.

5. *Over-negativism.* On page 416 of *The Dynamics of Human Adjustment* may be read the typical psychoanalytic statement: "The urge to create an art project, whether it be poetry or music, painting or sculpture, is the urge to do reparation for, and restore, the incorporated object for which guilt is felt." And, on page 532, there is this statement: "Love, then, grows out of envy of another person who is older, stronger, more beautiful, or more competent than he. . . . Looking at it in another way, love is a reaction

formation against hostility." Now there can be little doubt that one of the most valuable lessons we have learned from psychoanalytic delvings is that positive and "good" feelings, like the creative impulse, or the emotions of love, may actually originate as sequelae of, or reaction formations to, negative or "bad" feelings like guilt or envy. Of course they *may*. But this is not to imply that they always *must*. It is quite unreasonable to assume—as the analytic writers usually seem to do—that the native human drives are *all* negative ones, and that positive emotions are, as it were, sublimations or culturally acquired *additions* to these negative impulses. It may well be that human beings have innate *constructive* as well as destructive drives: that (as Maslow has theorized) they are *naturally* and *normally* creative; and that (as Jersild has hypothesized) they have some *primary* love impulses. That artists *sometimes* create out of an urge to do reparation for the incorporated object for which guilt is felt, and that adults *sometimes* love because of a reaction formation against their envy or hatred of the loved object, it would be futile to deny. But to maintain that creative art and object love *always* spring from underlying feelings of guilt or envy is, it would seem, to lean over backwards to find a negative basis for *all* positive feelings. This appears to be another unscientific psychoanalytic viewpoint which stems from the same source of error to which most analytic exaggerations owe their origin: the fact that, as yet, the analysts have rarely studied *normal* human beings.

This is no place for a systematic review of all the errors of present-day psychoanalytic writing; nor, for that matter, for a discussion of the innumerable valuable contributions to psychological knowledge that Freud and his followers have made and continue to make. It has merely been the intent of this reviewer to show that, at present, psychoanalytic source material is so often badly and unscientifically presented as to make it almost inevitable for even scholars like Professor Symonds sometimes to go astray in its employment. It is to the great credit of the author of *The Dynamics of Human Adjustment* that he has been so *seldom* over-hasty in his formulations as to allow the kinds of errors just quoted to slip into an otherwise very careful piece of work. In general, Dr. Symonds has done an excellent editorial job on the main body of psychoanalytic writings of the past 50 years; so that, as noted at the beginning of this review, he has managed to make the Freudian and neo-Freudian positions considerably more palatable, meaningful, and usable than virtually any other recent writer has done. In this fact lies the real strength of *The Dynamics of Human Adjustment;* and,

because of it, the volume should be invaluable to all those who study, teach, or apply psychological knowledge.

2505 University Avenue
New York 63, N. Y.

BOOKS RECENTLY RECEIVED

(There will always be two pages of book titles, listed in the order of receipt, i.e., the most recently received books will be found at the end of the list.)

———. Freedom of the Movies. Chicago: Univ. Chicago Press, 1947. Pp. 241.

MAURER, K. M. Intellectual Status at Maturity as a Criterion for Selecting Items in Preschool Tests. Minneapolis: Univ. Minnesota Press, 1946. Pp. 166.

RADKE, M. J. The Relation of Parental Authority to Children's Behavior and Attitudes. Minneapolis: Univ. Minnesota Press, 1946. Pp. 123.

FORD, M. The Application of the Rorschach Test to Young Children. Minneapolis: Univ. Minnesota Press, 1946. Pp. 114.

GARRETT, H. E. Statistics in Psychology and Education. (3rd ed.) New York: Longmans, 1947. Pp. 465.

BARKER, R. G., WRIGHT, B. A., & GONICK, M. R. Adjustment to Physical Handicap and Illness: A Survey of the Social Psychology of Physique and Disability. New York: Social Science Research Council, 1946. Pp. 372.

WOLFF, W. The Personality of the Preschool Child. New York: Grune & Stratton, 1946. Pp. 341.

KLUCKHOHN, C., & LEIGHTON, D. The Navaho. Cambridge: Harvard Univ. Press, 1946. Pp. 258.

LINK, H. C. The Rediscovery of Morals. New York: Dutton, 1947. Pp. 223.

EISENBERG, P. Why We Act as We Do. New York: Knopf, 1947. Pp. 261.

BAUMGARTEN, F. Die Psychologie der Menschenbehandlung im Betriebe. Zurich: Rascher, 1946. Pp. 304.

GUTTMACHER, A. F. The Story of Human Birth. New York: Penguin, 1947. Pp. 214.

CABOT, P. S. DEQ. Juvenile Delinquency. New York: Wilson, 1946. Pp. 166.

VERGARA, A. D. A Clinical Study of a Group of College Women's Responses to Poetry. New York: Teach. Coll., Columbia Univ., 1946. Pp. 159.

THE SMITHSONIAN INSTITUTION. Annual Report for the Year 1945. Washington: Government Printing Office, 1946. Pp. 484.

LOUTTIT, C. M. Clinical Psychology. New York: Harper, 1947. Pp. 661.

POPENOE, P. Sexual Inadequacy of the Male. Los Angeles: American Institute of Family Relations, 1946. Pp. 41.

FREUD, A. The Ego and the Mechanisms of Defense. New York: International Univ. Press, 1946. Pp. 196.

BRUMBAUGH, S. B. Democratic Experience and Education in the National League of Women Voters. New York: Teach. Coll., Columbia Univ., 1946. Pp. 115.

SIMMEL, E. Anti-Semitism: A Social Disease. New York: International Univ. Press, 1946. Pp. 140.

VAN KREVELEN, D. A. Het Eenige Kind. Utrecht: Bijleveld, 1946. Pp. 368.

BLAU, A. The Master Hand. New York: American Orthopsychiatric Assoc., 1946. Pp. 206.

CLAWSON, J. Psychology in Action. New York: Macmillan, 1946. Pp. 289.

THOMAS, D. S., & NISHIMOTO, R. The Spoilage. Berkeley: Univ. California Press, 1946. Pp. 388.

MICHOTTE, A. La Perception de la Causalite. Paris: Vrin, 1946. Pp. 296.

NATIONAL OPINION RESEARCH CENTER. Proceedings. Denver: Univ. Denver, 1946. Pp. 108.

CARTER, L. F. Psychological Research on Navigator Training. Washington: U. S. Printing Office, 1947. Pp. 186.

LEPLEY, W. M. Psychological Research in the Theatres of War. Washington: U. S. Printing Office, 1947. Pp. 202.

DAVIS, F. B. The AAF Qualifying Examination. Washington: U S. Printing Office, 1947. Pp. 266.

SHERIF, M., & CANTRIL, H. The Psychology of Ego-Involvements. New York: Wiley, 1947. Pp. 525.

SOROKIN, P. A. Society, Culture and Personality. New York: Harper, 1947. Pp. 742.
WHITE, L. The American Radio. Chicago: Univ. Chicago Press, 1947. Pp. 260.
KRACAUER, S. From Caligari to Hitler. Princeton: Princeton Univ. Press, 1947. Pp. 361.
ARCHIBALD, K. Wartime Shipyard. Berkeley: Univ. California Press, 1947. Pp. 237.
THURSTONE, L. L. Multiple-Factor Analysis. Chicago: Univ. Chicago Press, 1947. Pp. 535.
LINDNER, R. M., & SELIGER, R. V. Handbook of Correctional Psychology. New York: Philosophical Library, 1947. Pp. 691.
CATTELL, R. B. Description and Measurement of Personality. New York: World Book, 1946. Pp. 602.
ALSCHULER, R. H., & HATTWICK, B. W. Painting and Personality. (2 vols.) Chicago: Univ. Chicago Press, 1947. Pp. 590.
FORD, M. The Application of the Rorschach Test to Young Children. Minneapolis: Univ. Minnesota Press, 1946. Pp. 114.
RADKE, M. J. The Relation of Parental Authority to Children's Behavior and Attitudes. Minneapolis: Univ. Minnesota Press, 1946. Pp. 123.
WATSON, G. Action for Unity. New York: Harper, 1947. Pp. 165.
COLE, L., & MORGAN, J. J. B. Psychology of Childhood and Adolescence. New York: Rinehart, 1947. Pp. 416.
PORTEUS, S. D. And Blow Not the Trumpet. Palo Alto: Pacific Books, 1947. Pp. 304.
SEWARD, G. H. Sex and the Social Order. New York: McGraw-Hill, 1946. Pp. 301.
FLUGEL, J. C. Men and Their Motives. New York: Internat. Univ. Press, 1947. Pp. 289.
MANNHEIM, H. Criminal Justice and Social Reconstruction. New York: Oxford Univ. Press, 1946. Pp. 290.
LEIGHTON, D., & KLUCKHOHN, C. Children of the People. Cambridge: Harvard Univ. Press, 1947. Pp. 277.
KITAY, P. M. Radicalism and Conservatism toward Conventional Religion. New York: Teach. Coll., Columbia Univ., 1947. Pp. 117.
LANDES, R. The City of Women. New York: Macmillan, 1947. Pp. 248.
DICHTER, E. The Psychology of Everyday Living. New York: Barnes & Noble, 1947. Pp. 239.
FREUD, A., *et al.* The Psychoanalytic Study of the Child, Vol. II. New York: Internat. Univ. Press, 1947. Pp. 424.
GILBERT, G. M. Nuremberg Diary. New York: Farrar, Straus, 1947. Pp. 471.
LANDIS, P. H. Social Policies in the Making. Boston: Heath, 1947. Pp. 554.
THOMPSON, L. Guam and Its People. Princeton: Princeton Univ. Press, 1947. Pp. 367.
VON HENTIG, H. Crime: Causes and Conditions. New York: McGraw-Hill, 1947. Pp. 379.
BOWERMAN, W. G. Studies in Genius. New York: Philosophical Library, 1947. Pp. 343.
ALLPORT, G. W., & POSTMAN, L. The Psychology of Rumor. New York: Holt, 1947. Pp. 247.
FOX, H. M. The Personality of Animals. New York: Penguin, 1947. Pp. 116.

$8.00 per volume
Single Numbers $5.00

QUARTERLY
Two volumes per year

December, 1947
Volume 71, Second Half

Founded by G. Stanley Hall in 1891

THE PEDAGOGICAL SEMINARY AND JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior,
and Comparative Psychology

EDITED BY
CARL MURCHISON

John E. Anderson
University of Minnesota

Charlotte Bühler
Universität, Wien

Cyril Burt
University of London

Leonard Carmichael
Tufts College

Sante De Sanctis
R. Università di Roma

Arnold Gesell
Yale University

William Healy
Judge Baker Foundation,
Boston

Buford Johnson
The Johns Hopkins
University

Harold E. Jones
University of California

Truman L. Kelley
Harvard University

K. S. Lashley
Harvard University

A. R. Luria
Medico-biological
Institute, Moscow

Henri Piéron
Université de Paris

George D. Stoddard
University of Illinois

Calvin P. Stone
Stanford University

Lewis M. Terman
Stanford University

Godfrey Thomson
University of Edinburgh

E. L. Thorndike
Teachers College,
Columbia University

C. J. Warden
Columbia University

John B. Watson
New York City

Helen Thompson
Woolley
Teachers College,
Columbia University

Copyright, 1947, by The Journal Press
Provincetown, Massachusetts

Entered as second-class matter, May 11, 1937, at the post-office at
Provincetown, Mass., under the Act of March 3, 1879

The Journal of Psychology

EDITED BY

Carl Murchison

The Journal of Psychology was founded at the request of many psychologists throughout the world for the purpose of establishing a medium in which publication shall be immediate and in which other publication experiments may be carried out.

(1). The subscription price will be [illegible] per volume.

(2). The format of each volume will be such that each subscriber may tear down the assembled volume into its component articles.

(3). Except through the fault of the author, the lag in publication should not be more than three or four weeks.

(4). The author will receive 200 reprints of his paper, and subscriber will receive the accumulated publications bound into half volume units. The second half of each volume will contain the title page and table of contents for that volume. Each half volume unit will be mailed to the subscribers at its stated date.

(5). Each author will be charged the actual manufacturing costs of any cuts or halftone cuts.

(6). The publication charges will be as follows:

4	page	signature	$[illegible]
8	"	"	[illegible]
12	"	"	48.00
16	"	"	64.00
20	"	"	80.00
24	"	"	96.00
28	"	"	112.00
32	"	"	128.00
36	"	"	144.00
40	"	"	160.00

These charges are tentative and will be adjusted as justified by the subscription list (especially by the effect of the war in China and in Europe).

(7). The accumulated units will be mailed to subscribers quarterly: January, April, July, and October. The units may vary in size, to accommodate publication needs.

Two volumes annually. Per annum $14.00; per volume $7.00; per half volume unit $[illegible]. Complete sets at $7.00 per volume plus transportation.

THE JOURNAL PRESS

2 Commercial Street

Provincetown, Massachusetts

U. S. A.

$7.00 per volume
Single Numbers $4.00

QUARTERLY
Two volumes per year

December, 1947
Volume 71, Second Half

Founded by G. Stanley Hall in 1891

THE PEDAGOGICAL SEMINARY AND JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

If this space should be unstamped, this is the regular library edition. But if this space is stamped with a designating title, this is a special edition, sold under the restrictions of a bilateral contract, and may not be resold for a period of five years from date of publication.

DECEMBER, 1947

Copyright, 1947, by The Journal Press
Provincetown, Massachusetts

Entered as second-class matter May 11, 1937, at the post-office at Provincetown, Mass., under the act of March 3, 1879

The Journal of Genetic Psychology, 1947, 71, 155-175.

DEVELOPMENT OF A YOUNG BLIND CHILD*

Graduate Department, MacMurray College

J. Wilson and H. M. Halverson

Although much has been written about the blind, information concerning their behavorial development in early childhood is scarce.

We know of but one study in which an attempt was made to trace the development of an infant with severe visual defect. This study, very briefly presented, was conducted at the Yale Clinic (4). The subject was a girl infant with bilateral cataracts and low visual acuity. At 52 weeks her developmental level, according to the Gesell Schedules, was 40 weeks. Shortly after 18 months when her cataracts had been removed, her developmental level was above average. As a result of their findings the investigators made the surprising statement (p. 259), "Since watching Celia's development, we are much less lenient about attributing severe retardation in infancy to visual defects."

In reviewing the data in the above case it was disclosed that the subject's retardation before her operation was by no means excessive, and that she possessed some vision of practical value to her. At 40 weeks she reached for a toy held close to her eyes. At 18 months she exhibited "investigatory activities," and "more interest in lights than usual." Furthermore, she was reported to be very sure-footed in walking. From these data it is clear that her visual defect was not as severe as that of the subject of the present study.

Subject of the Present Investigation

The subject of our investigation, Billy, was born on July 14, 1943. His weight at birth was 7 pounds 13 ounces. When he was 3½ months old, it was noticed that he gave no response to a flash of light and that his eyes did not follow a moving light. Five eye specialists concurred in that his vision was far below normal due to an atrophied condition of the optic tract.

At six months he was taken to the Wichita Child Guidance Center where he was administered a battery of tests, viz., The Gesell Schedules, Cattell Infant Scale, Vineland Social Maturity Scale and a number of improvised

*Received in the Editorial Office on July 10, 1946.

tests. According to the report, Billy reacted normally for a 6 months' baby except in tests requiring vision.

Billy arrived at his present home when he was nine months of age and came to our attention one month later. The foster parents were a minister and his wife who had two adopted sons, 3½ and 5 years of age. The foster parents were intelligent and coöperative, and reliable in reporting data on Billy's behavior. Under their guidance Billy was permitted to develop for the most part on his own initiative without the benefit of special training.

We found Billy to be an attractive, strong, and physically healthy baby with large blue eyes and blond hair. In quiet periods he sat rocking forward and backward from the buttocks with his eyeballs rolled down.

Upon presentation of auditory or tactual stimuli he opened the eyes widely and rolled the eyeballs upward. When the eyes were open, the eyeballs were usually in motion but their movements were not coördinated. They moved in different directions and at different speeds. Sometimes one eye moved while the other remained fixed. These oculo-motor peculiarities and information obtained from the following tests and observations gave evidence that Billy was capable of discriminating only very gross brightness differences.

When Billy was sitting with head erect, a flash light was directed upon his eyes at a distance of six feet. On only one occasion of 18 trials given at 15, 18, and 21 months did he make any response to the light. On this occasion he sat still momentarily and rubbed his eyes. However, there was no certainty that he was reacting to the light, since cessation of activity and rubbing the eyes were frequent occurrences.

A second test was to confront him with obstacles as he crept about the room. Billy followed definite paths in creeping. When his back was turned a cardboard box was placed in his path. The assumption was that if, upon approaching the box, he stopped or reached for it he was probably aware of its presence. There were two sets of boxes, each set consisting of three boxes, a black, a white, and a gray. The larger set presented an 8" x 8" surface to the subject, the smaller set a 4" x 4" surface. Although the test was given with the six boxes on three occasions, at 16, 19, and 21 months, Billy consistently ran into them.

Our observations disclosed that Billy consistently closed his eyes to direct sunlight and had a preferred path in creeping, viz., toward the south window —the main source of light in the living room. However, he failed to reach for toys held close to his eyes or to give any other evidence that he was aware of their presence.

Subject's Development in Four Fields of Behavior

At the time this study began the only data bearing on Billy's developmental status were those received from the Wichita Child Guidance Clinic. Our first records were obtained on two visits to his present home. Since Billy was accustomed to strangers, rapport was easily established. The data from observations of his behavior on these occasions were supplemented by information furnished by the foster mother. Examinations were conducted with the Gesell Developmental Schedules at 15, 18, and 24 months, but for the most part the data presented were gathered during regular weekly observations. On occasions when he was making rapid progress in an activity, semi-weekly observations were made. Some of the tests the passing of which depended largely upon visual space perception were tried but were later discontinued.

Table 1 presents the list of tests passed by Billy, the age at which he passed each test, and the developmental age norms. The tests in which he failed are not shown.

In administering the tests we adhered to the instructions in all situations except those otherwise indicated. We took precautions against developing negativistic attitudes by discontinuing situations at the first signs of fatigue or disinclination to respond.

Beginning with the items on motor development, our data showed that Billy's sitting behavior compared favorably with that of seeing children. Although he was below the norm for Sitting Unsupported when he arrived at his present home, his improvement was so rapid that at one year he was able to pass all tests on sitting. In the most difficult of these tests, Pivots 180°, he was only one month retarded.

The motor tests in which Billy was most retarded were those relating to locomotion and prehension. According to our records of items passed (see Table 1) and items failed, Billy's retardation in these tests was as follows:

Creeping, 4 to 5 months.
Standing, 4 to more than 9 months.
Walking, 6 to more than 9 months.
Prehension, 6 to more than 18 months.

At the close of this study Billy at 24 months was unable to stand or walk independently, throw or kick a ball, or turn the pages of a book. He has made no attempts to grasp cubes or pellets tapped loudly into place on the table top. In the test, Grasps 2 Cubes in One Hand, the cubes were not presented on the table top but touched to the back of the hand so that they could be prehended by rotating the hand 180°.

TABLE 1

DEVELOPMENT IN MOTOR, ADAPTIVE, LANGUAGE, AND PERSONAL-SOCIAL BEHAVIOR FROM 9 MONTHS TO 24 MONTHS

	Billy's age in months when test was passed	Gesell age norms in months
Motor Behavior		
Sits alone for 1 min.	10	7½
Erects self from leaning forward	10	8¼
Turns to side and maintains balance	10	9
Attains prone from sitting	11	9
Attains sitting from prone	12	10
Pivots 180°	12	11
Grasps 2 cubes in one hand	13	13
Attains creeping position	14	10
Creeps	17	11
Stands: holds on, full weight	17	9
Attains standing with *E's* assistance	17	10
Walks: held by one hand	18	12
Pulls self to standing	19	11
Lowers self to sitting using support	21	11
Cruises, walks using support	21	11
Stairs: walks up on hands and feet, not on knees	24	18
Adaptive Behavior		
Bell: shakes spontaneously	15	9
Holds 2 cubes in one hand	15	13
Language Behavior		
Comprehends "patacake"	12	9
Incipient jargon	14	13
Uses jargon	15	15
Vocabulary: 10 words	18	18
Vocabluary: 20 words	21	21
Speech: 3-word sentence	24	24
Personal-Social Behavior		
Feeding: holds bottle	10	8
Feeds self cracker	10	9
Plays patacake	12	12
Coöperates in dressing	13	12
Coöperates in dressing with arms	15	15
Releases ball	15	15
Casts objects playfully	15	15
Feeds self, spills, when cup placed in hands	18	18
Lifts cup to mouth: drinks well, not replace	21	21
Feeds self cereal with spoon when spoon dipped for him	18	15
Feeding: handles cup well	24	24
Feeding: inhibits turning spoon	24	24

Retardation was greatest in the adaptive field of behavior. Billy has consistently failed in all tests of adaptive behavior listed at 15 months and at older age levels. At 15 months he was credited with performing two tests in adaptive prehension which seeing children succeed in passing before the end of, or soon after, the first year. At 24 months he has shown no ability in tower building with cubes, putting cubes in a cup, placing blocks in the formboard, drawing with a crayon, putting pellets in a bottle, etc. At this age seeing children can construct a tower of six to seven cubes. Billy has not built a tower of two cubes. His retardation in this field is already in excess of nine months.

Since he failed so completely in the field of adaptive behavior, Billy was tested repeatedly with some of the materials under conditions involving changes in procedure. The results obtained under these conditions with the book, tower, and round block and formboard appear later in this paper.

Billy was least retarded in the field of language behavior. His ability in the use of jargon and words compared favorably with that of seeing children. At 15 months he was using jargon in play situations and had command over a few consonants and syllable combinations, viz., *m, d, da, la,* and *ma*. However, his vocalizations were less spontaneous than those of seeing children. His first intelligible word was "down" which was associated with a game played by Billy and his foster mother. At 21 months he sang small parts of the hymns, *"Oh, Beautiful Savior"* and *"Jesus Loves Me."* The melodies were easily recognized but the words were not well articulated. Despite his ability in speech in the presence of people Billy at 24 months was still employing jargon in playing by himself.

The Language tests which he failed to pass at as late as 24 months were actually tests of adaptive behavior. To pass these tests the child must pat, name, or point to pictures, carry out directions in disposing of a ball, and name certain test objects, viz., knife, pencil, and ball. These tests occur at age levels, 15-24 months. Billy also failed in the 24-month test involving the use of the pronouns I, me, and you.

The pattern of development in personal-social behavior was similar to that in language behavior. Billy's performances in the personal-social situations compared quite favorably with those of seeing children except in tests of adaptive behavior included in this field. Thus, while Billy exhibited ability approaching that of seeing children in simple play, feeding, and dressing situations (see Table 1), he evidenced retardation ranging from 3-9 months in tests involving pulling a toy, carrying a doll, regulation of

toilet habits, showing or offering a toy, and communicating wants or needs by pointing, pulling, or vocalizing.

At this point it should be stated that in her training of Billy, the foster mother's attitude was one of helpfulness and encouragement without over-indulgence. Her aim was to instil self-confidence rather than daring, to manage him in much the same way that she would handle a seeing child, and to permit him to gain experience without hurrying him through babyhood. As a result, Billy had no specific training in the personal-social field of behavior, except for the limited practice in self-feeding received once each week beginning with the 18th month.

On these occasions he sat in the high-chair. A teaspoon was put in his right hand and a bowl of cereal placed before him on his table. The palm of his left hand was held against the bowl. Through practice of bringing toys to his mouth he had a well developed hand-to-mouth response. By means of a full palmar grasp close to the bowl of the spoon, Billy in his first experience with feeding tools at 18 months exhibited considerable skill in guiding the filled spoon into his mouth. Since he made no effort to dip the spoon into the cereal upon lowering his hand, the examiner took hold of his wrist and aided him with a scooping movement. At the close of our investigation, despite all encouragement, Billy had made no attempt to fill the spoon. All dipping movements had to be completed by the examiner before the spoon was raised to the mouth.

He was credited with passing three tests involving use of the cup. At 18 months he held the cup remarkably well when it was placed in his hands. At 21 and 24 months his performances with the cup showed further improvement. On these occasions the subject's hands were brought to the cup on the table top. He guided the cup skillfully to his mouth but did not replace it on the table top.

His success in passing the tests, *Releases Ball* and *Casts Objects Playfully,* was by no means a surprise, since casting objects was one of his favorite pastimes. Prehended objects, viz., rattle and bell, which emitted sound by shaking them, were retained. All other objects were repeatedly dropped. Their value consisted largely in the noise they produced on striking the floor.

Development of Locomotion

Of special interest to the investigators was the lack of spontaneity in the subject's movements and a disinclination to initiate movements which involved alteration of position or even extension of the arms. His preferred

posture throughout the second year was sitting. As late as 15 months he had made no attempt to acquaint himself with his surroundings either by exploratory movements of the hands or by moving about. His arms were generally flexed. Although he was alert to sounds and movements about him, when he was left to his own devices he was content to remain for long periods at the place at which he had been placed. He made no effort to grasp objects which were noisily put on the table before him. He did not exploit them when they were handed to him, except to bring them to the mouth. When he was placed on hands and knees, he remained in this position or slowly lowered himself to prone. Later, when he ventured to creep, he moved slowly and with utmost caution. Despite his ability to support his weight in standing, attempts to place him on his feet earlier than 15 months usually resulted in failure because of a marked tendency to assume the sitting posture. The subject's disinclination to move about aroused curiosity as to when and how locomotion would begin. Because of the complete lack of information concerning this aspect of growth in blind children, the development of locomotion in our subject was recorded in some detail.

The seeing child sits unsupported for a full minute at 7½ months, attains the creeping position at 10 months, and creeps at 11 months. When the present subject at 10 months exhibited good sitting behavior, there was a lapse of four months before he managed to get on hands and knees and an additional lapse of two months before he ventured to creep. When he attained the creeping position for the first time during the 14th month by raising the body from a prone posture, he remained on hands and knees for several minutes, occasionally raising the head and rotating it slowly from side to side. Limited creeping was exhibited at the end of the 16th month. He crept very slowly forward a few short paces, turned about, and retraced his path.

At 17 months the subject was able to proceed to creeping from both prone and sitting postures. When he was placed in the prone position, he first braced his palms against the floor so as to elevate the upper part of the body, and then pulled his knees up under him. When he was placed sitting, he put the palms of his hands on the floor at the sides and somewhat at the rear of the buttocks and, using the arms as props, eased himself slowly backwards to a supine position, after which he rolled to prone before rising on hands and knees. At 20 months he discovered a short cut in going from sitting to creeping. He leaned forward, placed the palms on the floor to support the weight of the upper trunk and head, drew his legs back beside

the hips and rose to his knees. Inquiry revealed that until these observations began the subject had never been placed in a creeping position.

At 17 months he began to increase the distance of his creeping excursions. At first he followed the procedure of moving forward and retracing his course. His movements were slow and the advancing hand was placed cautiously on the floor ahead before he shifted his weight and drew the leg forward. However, before the end of the 17th month, he was creeping cautiously about the room, feeling his way with his head which he characteristically held face downward. Thus, as he bumped gently into pieces of furniture, he absorbed the shock with the top of the head. Contact was at first followed by withdrawal. Later, the hand was extended and rubbed or brushed over the leg or seat of the object. At 18 months he was creeping from one piece of furniture to another and exploring them by hand and mouth. Before the end of this month he evidenced knowledge of the location of the various pieces of furniture by creeping directly toward them and raising the hand to a height appropriate to that of each object when he was within reaching distance.

Up to this time the subject had always been put on the floor at about the same location in the room. Since he appeared to be familiar with his surroundings from this point, he was placed on hands and knees at varying locations in order that we might observe how he oriented himself with reference to the room. The examiner held the subject in her arms, turned around slowly three or four times, then lowered him to the floor and stepped quietly to one side. At times he was placed facing the wall, and at other times facing the center of the room, always beyond arm's length from wall or furniture.

On these occasions the subject first assumed a sitting posture. He then extended the arms a little and moved the hands laterally in a small arc at waist level to feel about him. He next pivoted around slowly, renewed these seemingly searching movements, and, failing to contact any article of furniture, returned to the creeping position. He crept cautiously for one or two slow steps, extended an arm forward, and, if he failed to contact anything in his path, continued this slow progress until he found an object which, after moving his hand over it and mouthing it, he apparently recognized. He then took a position with reference to the object, and gave evidence of awareness of his location by creeping more rapidly and extending the arm on approaching other objects.

Despite the subject's reluctance to being placed upon his feet, when he

was held leaning against the side rails of his crib at 10 months, he demonstrated his ability to support his weight by remaining in this position for four or five seconds. The fact that he was supported from both front and rear may account for standing at this early date. In subsequent trials at standing, support was given from one direction. At 15 months we succeeded in getting him to support his weight in standing when he was held at the armpits. He sank immediately to sitting when the examiner withdrew her hands. At 17 months he was placed standing facing the examiner. When she spoke encouragingly to him and gradually withdrew her hands he merely leaned forward against her. She also attempted without success to elicit stepping movements by holding his hands and pulling him slowly forward. When she repeated this procedure at 18 months, he succeeded in sliding one foot ahead on the toes and dragging the other forward an equal distance. In the first stepping movements the entire weight of the body was on the toes. However, with five days of practice, walking with support was accomplished with short full-sole steps on alternate feet. Balancing was precarious. Gripping firmly the examiner's forefingers with both hands, he swayed laterally and forward and backward on widely spaced feet. At 21 months his ability in balancing had so improved that he walked holding on with one hand. His grip on the examiner's finger was relaxed and it was evident that he was using this finger more for a guide than a support.

At 19 months he pulled himself to standing. He had been creeping before the sofa, occasionally lifting a hand to it, when he came to a stop and brushed his right hand back and forth over the seat. Using this arm for support, he elevated himself to one knee, and then, bracing himself against the sofa, brought the left hand to the cushion and at the same time pivoted to the right until his chest was in full contact with the sofa. He now braced himself hard against the sofa and drew up the left knee. With his head bent forward and both arms extended across the seat he got one foot and then the other on the floor and pulled himself slowing to standing. He supported himself by leaning heavily against the sofa.

At 21 months his standing posture was quite erect, and he began to cruise along the sofa. He used a full-sole stance in cruising and balanced himself by sliding the hands on the seat of the sofa. At times he sidestepped his way; at other times he cruised with both feet pointed in the direction in which he was moving. As late as 24 months when this study ended, the subject had never been observed to stand or walk independently.

Auditory Perception of Direction

The experiment consisted in localizing a source of sound in a horizontal plane in front of the subject.

The source of sound was a small hand bell. Billy had early exhibited a marked preference for sound-emitting objects and was especially fond of the hand bell. It was believed that ringing the bell within arm's length would elicit reaching movements and that the directness of these movements would be an indication of the accuracy of localization. Since Billy's usual reaction to sound was to rotate the head in the direction of the source of the sound, the direction in which he faced was also recorded.

The subject sat on the floor midway of one side of an elbow-high table with his legs extended beneath it. The experimenter sat facing the subject from the opposite side of the table. The table top which was painted white was 30 inches long, 20 inches wide, and five inches above the floor. With the midpoint of the table edge directly under the subject's nose as the center, a semi-circumference, the radius of which was 10 inches, was described in black on the table top. Five straight black lines radiating from the midpoint intersected the semi-circumference at the median plane of the subject's body, and at 30° and 60° right and left of the median plane. The points of intersection were used in the presentation of the bell. The lines aided the experimenter in following the course of the reaching movements and tracing them on paper patterns of the table top.

The experiment was conducted at intervals of one week from the 15th month to the 24th month. Illness resulted in the loss of three sessions. Attempts to present the bell once at each of the five points at each session were not successful because of Billy's reluctance to surrender the bell after having secured it and later because of waning interest in the bell with increased confidence in creeping. From the 17th month to 20th month he frequently showed his disregard for the bell by creeping away before the bell could be presented. There was some renewal of interest for the bell at 21 months. The number of presentations was therefore first reduced to four and then to two. Eventually the bell was presented only at positions 30° right and 30° left of the median plane.

The experiment began with the examiner calling the subject by name. When he was facing directly ahead, the examiner with a few sharp wrist movements directed toward and away from the subject rang the bell immediately above the point at which it was to be placed and quickly released it. The examiner directed her attention upon the subject's face during the

ringing of the bell and then transferred it to the subject's reaching hand, the path of which she at once traced on the paper pattern. Billy was praised for each reaching effort and permitted to retain the bell for a short time whenever he succeeded in grasping it.

The experiment provided Billy his first experience in reaching for objects at a distance which required leaning forward from the buttocks. We do not mean to say that up to this time he had had no experience at all in reaching. Any activities of the arms which are directed at maintaining balance, handling toys, altering one's position or posture, etc., may be regarded as reaching movements. Besides, he had had some practice in reaching for the rattle sounded at varying points about the head.

The initial response to the ringing of the bell consisted in rotating the head until he faced directly the source of the sound. During this time hand movements were temporarily suspended. However, reaching occurred almost at once. If he succeeded in grasping the bell, it was immediately inverted, brought to the lips and tilted as though it were a cup. Shaking the bell slightly and bringing the other hand upon it usually followed. His reaching movements even at the start of the experiment were directed at a point immediately above the bell. It was only when the arm was fully extended that reaching took on the character of groping. Groping consisted of searching movements in which the hand, as it descended, swept laterally above the table top in the vicinity of the bell. However, so well was the hand directed that had Billy merely lowered it at the end of its approach he would in most instances have contacted the bell. Thus, while the groping movements were for the most part superfluous, their use at the time of this experiment had already become habitual. Incidentally, the hand was held pronated in an anticipatory grasping posture in groping. The fingers were semi-flexed and the thumb in opposition.

Left and right were never confused in localization. One hand was always used in reaching, the right hand when the sound was at the right and the left hand when the sound was at the left.

Table 2 presents data relating to the reaching responses to the bell at each of its four positions. The items are self-explanatory with the possible exception of the word *Sweeps* which refers to the lateral deviations of the hand in groping for the bell.

The table fails to show how well directed were the reaching movements. In fact one gains the erroneous impression that considerable difficulty was experienced in locating the bell. According to the data, the subject missed

TABLE 2

DATA RELATING TO THE REACHING MOVEMENTS IN LOCALIZING THE SOUND OF THE BELL AT 4 POSITIONS IN THE HORIZONTAL PLANE IN FRONT OF THE SUBJECT

Position of bell	*No. presen-tations*	No. times *grasps* bell	No. times reaches *but fails* to grasp	No. times *fails to* respond	No. of groping sweeps *before* grasping	Scope of *sweeps* (inches)
30°R	21	10	6	5	2 to 4	4-10
30°L	21	8	6	8	2 to 4	3-12
60°R	7	2	0	5	1 to 4	10-24
60°L	5	0	2	3	——	——

the bell on 12 of the 30 occasions in which reaching responses occurred at the two more frontal positions. However, six of the misses were due to under-reaching (failure in depth discrimination) and four to failure to lower the hand when it was extended above the bell. There was no reduction in the number of sweeps in groping for the bell. Contact with its handle usually required two or three sweeps. Because of decreasing interest in the bell, the sweeps were more carelessly executed and more extensive in scope at the end than at the beginning of the experiment. For example, the shortest sweeps for both hands occurred at 16 months and the longest sweeps at 22 and 23 months. As a result, there was no improvement with age in accuracy of groping or in speed of contacting the bell.

The subject's readiness in initiating the reaching movements, the directness of the approach upon the bell, and the well-directed head movements point to a fairly accurate perception of the source of sound.

AUDITORY PERCEPTION OF DEPTH

In this experiment the subject was required to localize a source of sound at varying distances in the median plane of the head. The conditions were the same as in the preceding experiment, with the exception that the bell was rung with short lateral wrist movements and, as nearly as possible, with equal force at distances of 5, 10, and 15 inches immediately in front of the subject. All three points were within reaching distance. Since adjustments of the head—raising or lowering it in accordance with the distance of the bell—were too indefinite to be informative, ability in depth discrimination was determined in terms of the accuracy of the reaching movements. The experiment was tried at 15, 19, and 21 months with the bell rung and placed at each of the three points designated above at each session. The results in brief were as follows.

Distance discrimination was evidenced at the first session. The subject reached farther for the bell at the 15-inch distance than at the 10-inch distance, and farther at the 10-inch distance than at the 5-inch distance. The reaching movements were more accurate at the 10-inch distance than at either of the other distances, although in each instance they ended in groping. There was no improvement in depth discrimination. Over-reaching occurred at each presentation of the bell at the 5-inch point and under-reaching at the three trials at the 15-inch point. The bell was always grasped at the 10-inch distance, knocked down and then grasped at the 5-inch point, and missed by 1-3 inches at the 15-inch point.

The results obtained in the above experiments on sound localization are in accord with the facts, viz., that right-left discrimination is good, whereas depth discrimination is relatively poor.

Tactual-Kinesthetic Localization

Because of the tender age of the subject, the experimental method commonly used with older children and adults, viz., that of requiring the subject to place the point of a stylus on the stimulated point of the skin, could not be employed. The localizing responses consisted in bringing the fingers of the localizing hand to rub the stimulated area. The responses were elicited by tickling with a small feather at predetermined points on the skin and by applying gentle pressure at various points on the arms and legs. Although the subject's localizing ability could be only roughly determined by this procedure, no other method suggested itself.

In the tickling experiment the tip of the feather was drawn lightly over the skin with a circular motion. The diameter of the area covered did not exceed 2 cm. The points stimulated were the lobes of the ears, the tip of the nose, and the dorsal surfaces of the wrists, elbows, and knees. Localizing responses to pressure were obtained at the wrists, elbows, sholuders, ankles, and knees. A rubber band encircling the limb at each of these points served as the stimulus for pressure. Rubber bands of the same thickness but of varying lengths were used. By selecting a band appropriate in length to the girth of the limb at each of the above points, pressure was approximately uniform for all points. The experimenter talked playfully with the subject as she slipped the band over the arm or leg and gently released it into position. These experiments were conducted at 17, 19, 21, and 24 months.

Appropriate responses to the location of the tickling and pressure stimuli occurred at the beginning of the experiments. In the tickling experiment the

right hand was used in localizing stimulated points on the left side of the body and the left hand in localizing stimulated points on the right side. The stimulated area was in each instance covered and rubbed. The tips of the four fingers were used in the operation; hence to the extent that at least one of the fingers contacted the area, localization was accurate for each point. The area covered in rubbing was as large at 24 months as at 17 months. This finding is in accord with those obtained with young children by Dunford (3), Renshaw (7) and Renshaw in coöperation with other investigators (8, 9).

The subject also used the appropriate hand in locating the rubber bands. They were more readily located on the arms than on the legs, more readily located at the wrists and elbows than at the shoulders and knees, and much more readily located at the knees than at the ankles. Contact with a band was always followed by attempts at its removal. By means of scratching movements he succeeded in curling 2 or 3 fingers under the band. He experienced no particular difficulty in removing the bands from the arms but had no success in removing them from the legs.

Results Obtained with Improvised Tests and Tests with Modified Procedures

Many of the materials used in testing seeing children possessed little or no stimulation value for our subject. This was particularly true of objects of prehension. It was evident that unless we obtained activity with these or similar materials, we should be unable to render a just appraisal of his ability in certain aspects of motor and adaptive behavior. Furthermore, it was by means of this activity that we hope to gain information concerning the way in which the subject achieved perception of tridimensional space. In some of the following test situations the examiner sought to acquaint him with the use of the materials and to promote activity by appropriate manipulation of the subject's hands, even to the extent of carrying out the required activity.

Goosey Gander Book. The examiner tapped the book sharply against the table top before placing it before the subject. After a short pause he cautiously extended his hands and placed them on the book. If he chanced to contact its edge, he sometimes raised the cover slightly but never turned the pages. The examiner then turned the pages with the subject's hand, but the activity ceased as soon as the examiner withdrew her aid. Despite continued use of this procedure from 15 months on, Billy has not turned the pages.

The Two-Cube Tower. This test also appears at 15 months in the Gesell Schedules. The examiner noisily built the tower within easy reach, then placed the palm of the subject's right hand twice against the two cubes, and on the latter occasion left the top cube in the subject's hand. The response to this procedure was either dropping the cube or bringing it to the mouth. The examiner therefore repeated the procedure and, in addition, after the top cube had been removed, guided the subject's hand so as to replace it on the other cube. When the top cube was now restored to his hand, no attempt was made to build the tower. This complete procedure was frequently repeated during the course of study without success.

Round Block and Three-Hole Formboard. The round block was first put in the subject's hands. The examiner then took the subject's right hand, gently moved the palm around the block a few times, after which the block was removed. The examiner next held the formboard before the subject, had him grasp it with the left hand, and then moved the right hand around the round hole. The round block was now replaced in the subject's right hand, while the examiner and the subject with his left hand held the formboard. Despite repeated trials with this procedure, the block was never brought into relation with the formboard. The procedure was also tried without success when the formboard was lying on the table top and the examiner guided the right hand and block into the hole.

Round Block and Hoop. Since the subject showed a preference for materials which could be easily manipulated, an embroidery hoop was substituted for the formboard. The hoop, inside diameter 3½ inches, was easily large enough to contain the round block. The examiner presented the block and the hoop singly and moved the subject's hands about the objects. The objects were then presented together, the block to the right hand and the hoop to the left hand.

The result was that the subject sat still so long as he held both objects. They were never brought close together. The block was usually released quickly, and the hoop retained but a short time. Taking the subject's hands and going through the appropriate activity, viz., repeatedly bringing the block into position within the ring, failed to bring a repetition of the activity when the hands were released. There was no evidence that the subject perceived the similarity in form of the two objects.

Tak-A-Part Dolly. The dolly consisted of three parts: a round head, a larger round trunk, and a flat wooden base at the center of which was erected a tall peg. Holes of larger diameter than that of the peg extended from top

to bottom through both trunk and head to permit slipping these parts in turn on to the peg so as to complete the dolly. The problem was to combine the parts.

Despite our efforts directed at showing him how to complete the dolly, viz., moving his palms over it and its parts separately, indicating the holes and peg, and using his hands to combine the parts, no two parts were ever brought close together. The fact that on presentation of the complete dolly it fell apart as he manipulated it, apparently carried no significance. He retained briefly the part remaining in his hands and ignored the fallen parts.

Rattle and Paper. When a paper, 8½ x 11 inches, was crumpled about the chamber of a small rattle and handed to the subject, he shook the wrapped rattle first with one hand and then with the other until the paper fell off. When the rattle was wrapped in paper and tied with a string, he repeated the above performance. When this activity failed to remove the paper, he held the wrapped rattle with both hands, scratched at the paper until he curled the fingers under the string, and managed to pull it off. The paper was then removed by shaking. Although this situation was reinstated several times during the last weeks of our study, he never held the rattle with one hand and removed the paper with the other.

Discussion

The subject's performances in the developmental schedules and in the other test situations employed in this study revealed a general retardation in development. The retardation was greatest in the motor and adaptive fields of behavior and least in language.

Out data indicate that his retardation as a whole was due to inadequate space perception. Although information concerning the development of space perception in the young blind child is lacking, the literature indicates that the notions of space of blind adults differ from those of seeing persons. According to reports (5, p. 205; 10, p. 331) they depend more upon audition than upon the sense of touch for their ideas of space. Research shows that congenitally blind individuals upon recovery of sight lack stereoscopic vision (1, 6) and make unsuccessful attempts to reach for objects (2). A survey of the tests to which the subject failed to respond or in which his performances were notably poor showed that these tests involved the use of movements the appropriate execution of which depended upon appreciation of space beyond the body. The fact that most of these tests are concerned

with motor and adaptive behavior accounts for the subject's marked retardation in these fields.

Motor and adaptive forms of behavior are for the most part concerned with outgoing activities, viz., various forms of prehension and locomotion. Prehension and locomotion call for relatively accurate perception of spatial facts and movements of precision. Of all the senses, vision furnishes the most exact and complete appreciation of space and the most objective and accurate directive cues for outgoing activities. The individual who is deprived of vision at birth is forced to depend upon the less definite tactual, kinesthetic, and auditory impressions for his notions of space. As a result, his perception of spatial facts, such as location, extent, and distance will be less definite than that of seeing children. Because hearing is his most important distance sense, his outgoing movements will probably be initiated in response to auditory stimulation. However, since hearing is a very subjective sense and auditory space perception is notably poor, except for right-left discrimination, such movements will be late in appearing and less well directed and less confidently executed than those of seeing children.

Since movements are an important factor in the development of space perception, their late appearance will further handicap him in perceiving the spatial relationships of his environment. With the above conditions in mind the marked retardation exhibited by our subject in all activities involving prehension and locomotion is not surprising.

In this connection one may well be asked to account for the subject's well directed reaching movements in response to the auditory presentation of the bell. In answer to this question it can be stated that localization of the bell necessitated only right-left discrimination and that the subject had already had four months' practice in reaching for a rattle presented informally at varying positions in the horizontal plane of the ears.

With reference to locomotion it can be said that the subject's marked retardation in standing and walking indicates that vision plays an important rôle in upright postures. According to the data, our subject was only 1-2 months retarded in sitting but was unable to stand or walk independently at 24 months. Developmentally, sitting, standing, and walking represent progressive stages in locomotion. In the development of these activities the seeing child makes appropriate motor responses to visual, kinesthetic, and tactual cues. Standing and walking, very precarious postures for the young child, develop later than sitting because they require a higher degree of inter-sensory-motor coördination. Visual cues serve as the directive

agents in locomotion, and as such, they aid in maintaining bodily equilibrium. In the development of locomotion from sitting to standing and walking, as the height is greatly increased and the area of the supporting base correspondingly reduced, visual cues become increasingly important for equilibration. Thus it is clear that blindness is a greater handicap to upright than to sitting postures.

When we compare the behavior of our subject with that of seeing children we begin to realize the significance of vision in the initiation and development of outgoing activities leading to prehension, locomotion and appreciation of space. To the seeing infant visual localization of an object is the first step in gaining possession of it. The object is first prehended by the eyes and later by the hands. Visual localization develops rapidly during the first two months of life, and active reaching movements in response to visual localization of objects occur as early as the third month and are so well directed at 6 months that grasping an object at a distance of 6 inches is a normal occurrence. Visual and manual exploration of objects begins at about 7 months and there is some evidence of form perception before the end of the first year. Visual stimulation from objects, persons, and their movements also serves as an incentive for locomotion. At one year the child creeps about the room or walks holding on to the furniture. During these excursions he frequently stops to examine objects with eye and hand. At 15 months he walks independently and his excursions soon cover the house. He is rapidly acquiring definite notions concerning space. In exploring and exploiting objects, and in moving from place to place, the visual, tactual, and kinesthetic senses are stimulated together, and collectively they furnish data for the perception of many spatial facts, such as location, extent, distance and form of objects.

In contrast to the positive and aggressive attitude of seeing children toward their environment is the lack of initiative and spontaneity in our subject's movements.

Audition played the leading rôle in acquainting the subject with his surroundings. His behavior at the start of this investigation clearly indicated that the ears were his primary exploring tools. Before and after he was able to creep, as he sat quietly on the floor for long periods, his attitude was one of constantly listening. At the least abrupt sound the restless eye movements came to a stop as he raised and turned the head to bring both ears to bear upon the source. He was unusually alert to the sound of distant voices, approaching footsteps, and the opening of doors. He followed

approaching and disappearing sounds with smoothly executed head movements. In the experiment with the bell, slight corrective adjustments of the head following rotation appeared to indicate that localization of sound was achieved by the process of balancing the intensities at the two ears.

His first acquisitive outgoing movements occurred at 11 months in response to a sound-producing object, the rattle, presented within easy reach at ear level. In addition to rotating the head to the sound, he began to reach for the rattle by sweeping the slightly extended arm right and left in the general direction he was facing. At first the rattle was so held as to insure success in reaching. Later, it was held farther away and at varying points about the head. At 15 months when the bell was introduced his groping movements were more confined, and resorted to only when the arm was fully extended. His other outgoing activities, creeping at 16 months and standing with support at 17 months, were also initiated in response to auditory stimulation, viz., vocal urging by mother and examiner.

There is another point to be considered in accounting for the subject's retardation in development. Our investigation finds the subject employing tactual and kinesthetic impressions in constructing his notion of space as it pertains to the parts of the body, then depending largely upon auditory and kinesthetic impressions in developing his notion of space beyond the body, and apparently experiencing difficulty in relating the two notions. It will be recalled that in the tickling experiment the subject employed tactual and kinesthetic impressions with considerable success in locating the stimulated points on the skin, yet he failed to make effective use of such impressions in acquainting himself with the spatial aspects of his surroundings. Now movements, such as reaching, handling of objects, locomotion, etc., are essential to an appreciation of spatial facts. In our subject, as we stated above, these movements occurred in response to auditory stimulation. In turning his head to sounds, in reaching for the rattle and bell, and in shaking them, auditory and kinesthetic impressions were being combined to give him his notions of distance and direction. Tactual cues were involved only incidentally in grasping and holding. Neither tactual nor kinesthetic impressions were employed in gaining detailed information of these objects. There was no poking, rubbing, fingering or transferring from hand to hand, of the bell or of other objects placed in his hand.

In view of the interest value of these objects for seeing children of his age, and their performances in similar situations, it would appear that tactual and kinesthetic impressions alone do not possess sufficient stimulation

value to elicit manipulatory activity, and that much of the value of touch as an informative sense in early childhood is due to its association with vision. Active exploration began with large objects as an orienting necessity. As late as 16 months he made no attempt to move from a sitting position or to extend his arms to feel about him. At 18 months, as he crept about the room, contact with objects was followed by withdrawal and change of direction. As the scope of his excursions increased and contacts became numerous, he began to explore the objects with hands and mouth. At 19 months awareness of the location of the various pieces of furniture was evidenced by differential anticipatory reaching movements on approaching the objects.

At the time this investigation was brought to a close there was still no active exploration of prehended objects, such as one finds in seeing children under one year of age. Test materials placed in his hands were soon released. Their value to the subject consisted in the noise they produced when they struck the floor. He anticipated the sound by turning the head to listen. Not only did he fail to explore objects, but he was unable to concern himself with more than one object at a time. Two objects, similar or dissimilar in form, when held in the hands, were never brought into relation; and the two hands never coöperated in activities involving more than one object. However, despite the lack of exploratory and coöperative activities, recognition of objects and form perception were undoubtedly present to some degree. The spoon and cup apparently were recognized as such and were also fairly well managed when they were favorably presented.

All in all, our findings appear to indicate that space perception in our subject was not a single united experience. Space perception is a unifying process, viz., the combing of various sensory impressions into spatial units or patterns. The unifying process is accomplished primarily through vision and touch, since it is in these senses that the impressions are spread out spatially in an ordered arrangement in correspondence with their external stimuli. However, visual impressions are the more precise, and the visual field of space is more objective and homogeneous than that of touch. Thus it is not surprising to find in our subject, who deprived of vision at birth is now only beginning to utilize the less definite tactual impressions, a less accurate and less complete appreciation of space than that exhibited by seeing children. By the same token, it is not surprising to find our subject's development retarded in activities involving outgoing movements.

Summary

Study of a blind boy during the second year of life by means of a battery of tests and experiments revealed a general retardation in his development. His retardation was greatest in motor and adaptive forms of behavior which involved adjustments to his physical environment and least in language. The discussion of our findings presents reasons why we believe his retardation was for the most part due to inadequate perception of space.

References

1. Carr, H. A. An Introduction to Space Perception. New York: Longmans, Green, 1935. Pp. xi and 413.
2. Dennis, W. Congenital cataract and unlearned behavior. *J. Genet. Psychol.*, 1934, **44**, 340-351.
3. Dunford, R. E. The genetic development of cutaneous localization. *J. Genet. Psychol.*, 1930, **37**, 499-513.
4. Gesell, A., et al. Biographies of Child Development. New York: Hoeber, 1939. Pp. xvi and 328.
5. James, W. The Principles of Psychology. New York: Holt, 1890. (Vol. 2.) Pp. vi and 704.
6. Latta, R. Notes on a case of successful operation for congenital cataract in an adult. *Brit. J. Psychol.*, 1904, **1**, 135-150.
7. Renshaw, S. The errors of cutaneous localization and the effect of practice on the localizing movement in children and adults. *J. Genet. Psychol.*, 1930, **38**, 223-238.
8. Renshaw, S., & Wherry, R. J. The age of onset of ocular dominance. *J. Genet. Psychol.*, 1931, **39**, 493-496.
9. Renshaw, S., Wherry, R. J., & Newlin, J. C. Cutaneous localization in congenitally blind vs. seeing children and adults. *J. Genet. Psychol.*, 1930, **38**, 239-248.
10. Titchener, E. B. A Textbook of Psychology. New York: Macmillan, 1910. Pp. xx and 565.

MacMurray College
Jacksonville, Illinois

The Journal of Genetic Psychology, 1947, 71, 177-185.

CONSTANCY OF *IQ* IN MENTAL DEFECTIVES*

Lincoln State School and Colony, and the Department of Public Welfare of the State of Illinois

WILLIAM SLOAN AND HARRY H. HARMAN

A. INTRODUCTION

This study is an attempt to verify previous studies concerning the hypothesis that the *IQ* of mental defectives decreases as the subjects grow older. It has been found, generally, that children whose *IQ*'s are high at an early age tend to get higher *IQ*'s as they grow older; and conversely, those whose *IQ*'s are low at an early age, tend to get lower *IQ*'s.

The consensus of all these studies seems to be toward the proposition that the rate of mental growth is not the same for children with varying levels of mental capacity. It is probable also that if normal children have a leveling off in the rate of mental growth at about the age of 13, then the same leveling off may occur earlier for children of subnormal intelligence, because they are reaching the maximum of their mental ability at an earlier chronological age. This same hypothesis may serve to explain why children of supernormal intelligence continue to gain after normal children have reached their peak of maturation. If it is true that subnormal children gain proportionately less in mental development at an earlier age than normal children, then it may be incorrect to apply to them the same growth curve formula which is applied to normal children.

As pointed out by Stoddard and Wellman:

> Numerous studies in the literature have indicated the tendency for institutionalized feebleminded to decrease in *IQ*. Kuhlmann, whose study in 1921 deserves mention because of its comprehensiveness, reports an average yearly decrease of 2.19 points for morons, 1.04 for imbeciles, and .37 for idiots. Hilden found a decrease over one year of 7.8 points. Davenport and Minogue report about a two-point yearly loss for a group of approximately 70 boys retested annually for six years (3).

On the other hand, Poull (2) reports that 126 defectives tested and retested on the Stanford-Binet at intervals of six months to three years and whose ages on the first test ranged from four to 28 years, with an *IQ* range

*Received in the Editorial Office on August 11, 1946.

of from 20 to 90, showed an average increment on the second test of 1.28 points. She reported that the range in the middle 50 per cent of the group changed from minus 3.3 to plus 4.8 points.

B. Description of Sample

The information used in this study was obtained from the files in the Psychological Department of the Lincoln State School and Colony at Lincoln, Illinois. The data were collected in the spring of 1943 and only those individuals who were patients in the institution at that time were included in the study. From the card files there were extracted the name, *CA*'s in the first, second, and any succeeding tests, and the corresponding *IQ*'s for each patient. All patients who had had two or more tests were included in the study, with the following exceptions. (*a*) Any case in which one or more of the tests had been given before 1920. It was felt that examination with the Stanford-Binet, prior to this date, may have had some questionable validity because of the short number of years of experience with the test. (*b*) Those cases in which the *IQ* had been obtained by the use of a test other than one of the revisions of the Binet test. (*c*) Those cases in which the *CA* on the test was less than three years. (*d*) All cases in which the *IQ* was 100 or more.

All tests were administered by the psychologists of the Lincoln State School and Colony, who had to possess certain minimum qualifications in order to obtain such position. There still may be some differences in testing which may produce changes, because of the different examiners over the years. On the other hand, it must be pointed out that in many instances the same individual gave both tests, and that in not any case was the examiner aware of the use to which the data are being put at the present time. It is true, of course, that with such large numbers as are included in this study the factor of difference in examiners may be thought of as a variable which should produce no consistent bias.

Because of the relative unreliability of the results obtained from patients who test with mental age under three years, it was decided to distinguish these cases from the remainder, but still to retain them in the total study so that any special work on low-grade patients would not be lost and so that the total sample would not be reduced too greatly. All *IQ*'s obtained prior to 1938 were corrected so that in all cases the divisor in the formula for the *IQ*'s was 15 years for adults.

There were 1,446 patients whose records were used in this study. All

of these had had at least two tests, some had as many as eight. Each pair of successive tests for an individual patient was taken to represent a "case," in the sense that it represents a period of time in which his *IQ* may have changed. For example, if an individual had three tests, he would contribute two cases to the study, viz., a comparison of the first and second tests, and a comparison of the second and third tests. A comparison of the first and third tests would not be included as an independent case because such a comparison would be related to the two cases included. The total number of pairs of successive tests (cases) was 2,267.

C. Analysis and Findings

The distributions of patients and cases are shown in Table 1. The first striking observation is that precisely twice as many patients lost in *IQ* as those who gained. When additional retests are considered, it is found that 711, or 31 per cent of the 2,267 cases had an increase in *IQ*, while 1,375 or

TABLE 1
NUMBER OF CASES, SHOWING DIRECTION OF CHANGE IN *IQ*

Cases	Total cases			Increase in *IQ*			Decrease in *IQ*		
	M	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*
				All cases					
Unique patients	738	708	1,446	206	237	443	478	404	882
Only one retest	463	465	928	117	143	260	307	272	579
First retest	275	243	518	89	94	183	171	132	303
Additional retests	431	390	821	131	137	268	272	219	491
Total cases	1,169	1,093	2,267	337	374	711	750	623	1,373
Per cent of total	100	100	100	29	34	31	64	57	61
				Cases with *MA* <3 only					
Unique patients	125	131	256	26	39	65	92	80	172
Only one retest	64	95	159	9	27	36	52	60	112
First retest	61	36	97	17	12	29	40	20	60
Additional retests	68	33	101	25	12	37	40	18	58
Total cases	193	164	357	51	51	102	132	98	230
Per cent of total	100	100	100	28	31	29	68	60	64

61 per cent, of the cases had a decrease in *IQ*. The remaining 8 per cent represents those cases for whom no change in *IQ* was found. Of the total cases, 357 or 16 per cent, were those with *MA* less than three years. In this selected group the relative proportion of cases which show a decrease in *IQ* was slightly greater than for the entire sample.

An indication of the total number of cases obtained from the varying number of tests taken by the patients is presented in Table 2. Of the 1,446 patients, 928 or 64 per cent had only two tests, and 324 or 23 per cent had three tests each; and the remaining 13 per cent of the patients had from four to eight tests each, decreasing in number as the number of tests increased.

TABLE 2
NUMBER OF TESTS TAKEN BY EACH PATIENT

Number tests	Number of patients M	F	T	Resultant number of cases M	F	T
2	463	465	928	463	465	928
3	177	147	324	354	294	648
4	62	64	126	186	192	378
5	21	21	42	84	84	168
6	9	5	14	45	25	70
7	5	4	9	30	24	54
8	1	2	3	7	14	21
Total	738	708	1,446	1,169	1,098	2,267

In discussing the concepts of age and *IQ* the problem arose as to whether to consider the age and the *IQ* at the time of the first test, at the time of the last test, or at some intermediate point. In attempting to solve this problem three measures of age were evolved, namely: (*a*) initial *CA*, the age at the time of the first test; (*b*) terminal *CA*, the age at the time of the last test; and (*c*) mid *CA*, the age halfway between the initial and terminal *CA*'s, regardless of the number of tests involved. The same device was used in describing *IQ*'s.

Data on chronological age (initial, mid, and terminal) are presented in Table 3. From this, it is evident that the median span of time between the first and the last test in the whole group was 5.5 years. The arithmetic mean for each of these measures of age is consistently about two and one-half years greater than the respective median. This positive skewness is to be expected from the nature of the sample, which includes cases selected with a minimum age of three years and an unlimited maximum age. The standard deviation is 10 years at the initial age, and increases slightly at mid-age, and again in the cases of the terminal age. However, the relative variation is really less at the terminal age than for the other two age distributions.

In reporting data on *IQ* the scheme of initial, mid, and terminal measures was used. For each of these measures the derived statistics are given in

TABLE 3
SIMPLE CHARACTERISTICS OF CHRONOLOGICAL AGES OF PATIENTS
(All ages in years)

Statistic	Initial *CA* *M*	*F*	*T*	Mid-*CA* *M*	*F*	*T*	Terminal *CA* *M*	*F*	*T*
Total patients	738	708	1,446	733	703	1,446	738	708	1,446
Range		3-60+			3-60+			3-60+	
Mean	14.2	15.5	14.8	17.3	18.4	17.8	20.4	21.2	20.8
Median	11.3	13.2	12.1	14.4	15.9	15.0	17.3	18.0	17.6
Skewness	0.82	0.74	0.81	0.78	0.78	0.81	0.78	0.92	0.85
Standard Deviation	10.6	9.3	10.0	11.1	9.6	10.4	12.0	10.4	11.3
Probable Error	7.1	6.3	6.7	7.5	6.5	7.0	8.1	7.0	7.6
Coefficient of Variation	74.6	60.0	67.6	64.2	52.2	58.4	58.8	49.1	54.3

TABLE 4
SIMPLE CHARACTERISTICS OF *IQ* OF PATIENTS

Statistic	Initial *IQ* *M*	*F*	*T*	*M*	Mid-*IQ* *F*	*T*	Terminal *IQ* *M*	*F*	*T*
Total patients	738	708	1,446	738	708	1,446	738	708	1,446
Range	1-95	1-90	1-95	1-95	1-85	1-95	1-99	1-90	1-99
Mean	51.6	48.4	50.0	49.2	46.6	47.9	46.9	45.0	46.0
Median	53.3	50.6	51.9	51.0	48.9	49.9	47.8	47.0	47.4
Skewness	—0.32	—0.40	—0.35	—0.34	—0.43	—0.38	—0.16	—0.36	—0.25
Standard Deviation	15.7	16.5	16.2	15.8	16.0	16.0	16.8	16.5	16.7
Probable Error	10.6	11.1	10.9	10.7	10.8	10.8	11.3	11.1	11.3
Coefficient of Variation	30.4	34.1	32.4	32.1	34.3	33.4	35.8	36.7	36.3

Table 4. The *IQ*'s of the patients range from 1 to 99. The upper limit was set arbitrarily as described above.

The mean initial *IQ* for the sample was 50; the mean mid-*IQ* was 48; and the mean terminal *IQ* was 46. The respective medians were 51.9, 49.9, and 47.4. At each stage of measuring *IQ* a slight negative skewness is evident. The amount of dispersion for each measure of *IQ*, given by the standard deviation, is consistently between 16 and 16.7. Although the *SD* of *IQ* is greater than that for *CA*, these should *not* be compared directly: for the relative variation in *IQ* is half of that in age (indicated by the coefficents of variation).

The data on time intervals between successive testings are presented in Table 5. The time intervals were put in classes of six months, except that all retests which occurred after 12 years were grouped. The bulk of the retests were given within four years, but in a few instances the time between the original test and the retest was as much as 20 years.

TABLE 5
SIMPLE CHARACTERISTICS OF TIME INTERVALS BETWEEN SUCCESSIVE TESTINGS

Statistic	Male	Female	Total
Total cases	1,169	1,098	2,267
Range		1 month to over 12 years	
Mean	4 yrs. 0 mos.	3 yrs. 8 mos.	3 yrs. 10 mos.
Median	2 yrs. 10 mos.	2 yrs. 7½ mos.	2 yrs. 8 mos.
Skewness	1.01	1.02	1.04
Standard Deviation	3 yrs. 5 mos.	3 yrs. 4 mos.	3 yrs. 4 mos.
Probable Error	2 yrs. 3 mos.	2 yrs. 3 mos.	2 yrs. 3 mos.
Coefficient of Variation	84.4	89.0	86.7

In the summary by Anderson (1) he has indicated that a number of investigators have commented on the decrease in the correlations of successive measures with an initial measure. Summarizing the studies by Honzik and Bayley on normal children, he reports *a striking decrease in correlations as we move away from initial status, and an equally striking increase as we move toward terminal status.* We were interested in seeing whether our data would show the same trend as found by Honzik and Bayley. However, instead of having a fixed sample tested at fixed intervals, our data consisted of varying numbers having several testings. Therefore, we correlated the *IQ* on initial testing and second testing for the closest relationship, and the *IQ* on the initial testing and terminal testing for the greatest span.

These correlations were .912 and .864, respectively. Since two-thirds of the patients had only two testings, the latter correlation must perforce have been very high. We would expect that had there truly been a greater lapse of time, the latter correlation would have dropped more. Selecting out the 518 patients who had taken more than two tests, and correlating their initial and terminal *IQ*'s, the result was .761. These results are in substantial agreement with those found by previous investigators. In general, then, for our population we may state that the greater the interval between testings, the greater will be the loss in the reliability coefficient of the test.

Comparing the reliability coefficient with those obtained by McNemar, we found that the latter reports reliabilities ranging from .80 to .99 for the data on the 1937 Revision of the Binet. In general, the reliability is about .90. Our reliabilities range from .76 to .91. Since the standardization population was relatively normal the decrease in correlation for our group may be explained, in part, by the fact that we have a population whose *IQ* is relatively less constant.

The correlation between the initial *IQ* and the difference in *IQ* between

first and last tests for the 1,446 patients was obtained next. This was done in order to determine whether or not there is a relationship between the various *IQ* levels and the amount of change in *IQ*. This coefficient was —.19 and was not significant. Apparently as we go up or down in the *IQ* scale, in this sample, the degree of fluctuation of differences in *IQ* varies independently. While this correlation is not significant, the fact that it is in the negative direction would lend evidence to the hypothesis that loss in *IQ* would increase as we go down in the mental scale. It may be stated in another way. Normal children lose none, morons some, imbeciles still more, and idiots most. This would be the logical order. While our data only suggest such an order, there is no support for Kuhlmann's findings indicating a reverse order.

As the next step in the analysis of the 2,267 cases, a distribution was made of the differences in *IQ*'s. The classes of the frequency distribution include three *IQ* points, and the range of differences in *IQ* goes from a gain of 28 points to a loss of 40 points. It is apparent that the distribution roughly approximates a normal curve, with the hump (or mode) occurring on the negative side.

Precise statistics based on these distributions are set forth in Table 6. For all cases the mean difference was a drop of 2.6 points, while the median was a loss of 2.2 points. The average loss in *IQ* was 0.4 points greater for the group of cases with mental age less than three years.

In addition to summary statistics for the entire distribution of differences in *IQ* there are presented in Table 6, separate statistics for the positive and negative sections of the range. Out of the total of 2,267 cases, there were 183 for whom the *IQ* was identical on one test and the retest; 711 showed some gain on the retest; while 1,373 showed a loss upon retesting. For those who gained in *IQ* the mean was 4.7 points and the median was 3.8 points. The average loss in *IQ* for all those with negative differences was even greater. The mean loss was 6.7 points and the median loss was 5.5 points for the 1,373 cases whose *IQ*'s were reduced upon retesting.

The distribution of variation in *IQ*, regardless of algebraic sign, also was considered (but the data are not shown in Table 6). The 2,267 cases were grouped in intervals of three points difference in *IQ* (gain or loss). The distribution presents what might be described roughly as a reverse *J*-shaped curve, with the big hump at a difference of three *IQ* points and a very gradual and steady decline out to a difference of 39 points. The mean variation in *IQ* was 5.4 points and the median was 4.3 points.

TABLE 6

SIMPLE CHARACTERISTICS OF DIFFERENCES IN *IQ*

Statistic	All differences						All cases with positive differences only			All cases with negative differences only		
	All cases			Cases with $MA < 3$ only								
	M	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*
Total cases	1,169	1,098	2,267	193	164	357	337	374	711	750	625	1,373
Range		—10 to +28			—31 to +28			+1 to +28			—10 to —1	
Mean	—3.0	—2.1	—2.6	—3.9	—1.8	—3.0	—4.9	—4.6	—4.7	—7.0	—6.4	—6.7
Median	—2.8	—1.5	—2.2	—3.4	—1.7	—2.6	3.9	3.8	3.8	—5.9	—5.1	—5.5
Skewness	— .086	— .27	—0.18	— .19	— .04	— .15	.75	.75	.73	— .67	— .77	— .71
Standard Deviation	6.4	6.7	6.5	7.9	8.1	8.0	4.0	3.2	3.7	4.9	5.1	5.1
Probable Error	4.3	4.5	4.4	5.3	5.5	5.4	2.7	2.1	2.5	3.3	3.4	3.4
Coefficient of Variation	213	319	250	203	450	267	82	69	79	70	80	76

D. Summary

From the simple statistics presented there is a clear indication that mental defectives do not maintain a constant *IQ*, but tend to decrease in mental level as they grow older. There were almost twice as many cases that lost in *IQ* as those which gained, and the variation was relatively greater for the group which decreased in *IQ*. The mean loss was 2.6 points; 31 per cent had a gain in *IQ* while 61 per cent showed a loss. Reliability coefficients show a tendency to decrease with increase of interval between testings. Changes in *IQ* are not related definitely to level of intelligence within the group, but the average loss in *IQ* may be assumed as representative for the entire group of institutionalized mental defectives.

E. Conclusions

This study is in agreement with previous studies which indicate that the *IQ*'s of mental defectives tend to decrease. As all of the subjects in this study were institutionalized defectives, no conclusion can be based upon the effect of institutionalization, since there was no control group. The loss in *IQ* may be attributable to other factors. It is suggested that the variation in the growth curve for defectives may be a factor which is operative. Further studies showing the relationship between change in *IQ* and age at time of change, are desirable. Correlation between stability of *IQ* and length of institutionalization also is necessary.

References

1. Anderson, J. E. The prediction of terminal intelligence from infant and preschool tests. *Nat. Soc. Study Educ., 39th Yearbook*, 1940, Part I, 385-404.
2. Poull, L. E. Constancy of *IQ* in mental defectives according to the Stanford Revision of Binet tests. *J. Educ. Psychol.*, 1929, **12**, 323-324.
3. Stoddard, G. D., & Wellman, B. L. Environment and the *IQ*. *Nat. Soc. Study Educ., 39th Yearbook*, 1940, Part I, 426-427.

Lincoln State School and Colony
861 South State Street
Lincoln, Illinois

The Journal of Genetic Psychology, 1947, 71, 187-194.

THE PSYCHOLOGICAL FOLLOW-UP STUDY OF A CASE OF LEAD POISONING*

Division of Psychiatry, Department of Medicine, University of Chicago

ANNA S. ELONEN AND MARY A. ONKEN[1]

One of the cases of lead encephalopathy reported by Haverfield, Bucy, and Elonen (2) in 1940 was that of a boy whose fraternal twin had not suffered from the disease. Although the boys are not identical twins, it was felt that the situation provided some degree of control for observation of the effects of lead poisoning associated with an encephalopathy. The case was accordingly followed, and the present report reviews briefly physiological, neurological, and psychological findings to the present time.

The history at that time revealed that the patient Roy and his fraternal twin Ray had both eaten painted plaster. The mother had administered castor oil which had been retained by Ray but vomited by the patient, Roy. Ray recovered but Roy was finally hospitalized after a six weeks' period of illness ending in a clonic convulsion.

At the time of admission, at the age of two years, the patient's head was enlarged and there was dilatation of the superficial scalp veins. Macewen's sign was present and there was papilledema of 2-2½ diopters. Pupils were equally dilated and reacted slowly to light through a small range. Nystagmus was absent, conjugate movements of the eyes were not restricted and the remaining cranial nerves were normal. Abdominal reflexes were absent. Sensation and muscular strength and coördination were not impaired. The child had some difficulty in maintaining his balance on walking and sitting. After the operation (a suboccipital decompression) had been performed, the papilledema gradually subsided and cerebrospinal fluid pressure returned to normal. His optic discs remained possibly paler than those of his twin brother but visual acuity has been excellent. On February 28, 1946, the patient was again seen by Dr. Paul C. Bucy. The boy was then 13 years of age and progressing well. The suboccipital wound was well healed and the decompression was flat and filled in with bone. The patient's speech was normal and

*Received in the Editorial Office on September 12, 1946.

[1]The writers are indebted to Dr. Paul C. Bucy of Chicago who originally referred the case, who has seen the patients again, and who has given us the physiological findings.

visual fields were full. Visual acuity was good but there was definite bilateral optic atrophy with pale discs, large cups, and a large area of the lamina cribrosa visible. These changes were more marked on the left side than on the right. The cranial nerves were otherwise normal. Sensation was everywhere intact and muscular strength, tone, and coördination were normal. The tendon reflexes in the upper extremities were rather sluggish, but equal, while those in the lower extremities were active and equal. Station and gait were normal. The only persisting physical abnormality, the optic atrophy, is secondary to the papilledema which was present. The patient remains neurologically normal with no evidence of any sequel to the initial disease. Ray's physiological history is completely negative.

Unfortunately no objective records are available on the developmental rates of the two boys, and so the mother's report must be relied upon. According to her report, teeth appeared at seven months in both of the boys. Ray sat up a month earlier than the patient. He also began to talk about a month earlier, for Ray's speech began at 12 months in contrast to the patient's, which was at 13 months. There is some discrepancy in the mother's report on their walking. The earlier report stated that both boys walked at 13 months whereas later she reported the patient to have walked a month later than his twin. In general, she did not recall any great differences between them even though, on the whole, the patient's development was not quite up to that of his brother. However, according to this, the patient's development is not at all retarded, for the appearance of the different stages of development are definitely within the normal limits. One, therefore, can be reasonably safe in assuming that before the plaster eating episode the patient's development had been at least that of the average child. It is of interest that although Roy's, the patient's, functional development has apparently always been a little behind that of his twin brother, Ray, he is physically much larger. He is taller and heavier. His muscular development is greater and he is definitely stronger than his twin brother.

On January 7, 1938, both boys were given a Revised Stanford-Binet, Form *M*. When the results are compared, it is found that patient obtained an *IQ* of 79 while his brother Ray earned a definitely higher rating with an *IQ* of 98. Patient's mental age was four years two months, which was exactly a year lower than that of Ray. The basal age for the patient was III-6 years, a half-year below his brother's and his total range reached only to Year V, as compared with Ray's upper limit at Year VI.

In the patient's test performance, auditory rote recall was poor. Instead

of completing analogies with a correct word, he merely repeated one of the words already given. There was also a slight tendency to perseveration, for he gave the same answer to two successive questions even though the questions were not related. In giving answers to problem situations, he showed a tendency to repeat learned information related to the subject matter, but did not adapt the information to the problem at hand. He demonstrated only slight comprehension of numbers, but like his brother he could count to three. When he was supposed to tell what was missing in certain mutilated pictures, he did not see details at all and merely gave the name of the object. In the same manner, his drawing was mere outline in comparison with the great detail given by Ray. In addition the patient was unable to recall a bead chain design which was reproduced rather easily by his twin. The patient could not define terms at Year IV-6, whereas Ray not only defined words but also gave differences between terms at Year VI.

Observed behavior was also markedly different, for the patient, though friendly and coöperative, was rather passive in his manner. His actions were slower and more deliberate than Ray's, and yet did not produce as certain results. It took twice as long to test the patient because his reactions were so much slower, and his speech was so indistinct that many of his answers had to be repeated. His speech was, as a matter of fact, so difficult to understand that his mother had to act as interpreter for a number of his responses. He did not burst into a fluent flow of conversation as his brother did. It was interesting to note that the mother felt that the patient's missing teeth were chiefly responsible for his defective speech, for Ray still had all his baby teeth. This was felt to be part of her concern for the patient; she did not seem to be at all anxious about Ray.

Ray's spontaneity and activity were in decided contrast to the patient's behavior. He was interested not only in the test but in everything else he saw, and related all the things he had done recently. It was also interesting to note how much detail was observed and commented upon throughout the test. In items involving comprehension he usually gave more than one solution. He adapted to new situations far more readily than the patient. In contrast one was much more aware of the patient's lack of personality.

When the twins were next seen, on August 9, 1939, they were given both the Revised Stanford-Binet (*L*) and the Arthur Performance Scale. At this time the patient obtained an *IQ* of 82 on the Stanford, mental age 5 years 7 months, as compared with Ray's *IQ* of 106 and mental age of 7 years 3 months.

The patient's basal had been raised by a half-year in the 18 months' interval, and his ceiling now was Year VII. As before, there was marked difficulty with rote recall. The same perseverative tendencies were still noted; once started on giving a certain response, he would give that response on the successive items even though there was no similarity in the stimulus word or question. This was particularly true of the vocabulary words. Number concepts had not changed appreciably in the test interval. More details had crept into his drawings and also into his descriptions and recognition of pictures.

The basal age established in Ray's examination was at Year IV-6, only six months above that of the earlier test, but the range now extended through Year XI, in marked contrast to the patient's limited performance. His vocabulary was at the VI-year level. Like the patient, he was weak in rote memory but the first failure in this type of test was a half-year higher than patient's. Although he failed the rote memory tasks at Years VII and VIII he was able to reverse four digits at Year IX. His recognition of absurdities began a shade lower than patient's, but he continued the task through a much higher level. His drawings were unusually clear-cut and exact in detail. Visual recall, which reached Year XI, was his best performance and was superior to his own planning of designs. His comprehension of general situations was good and his recall of reading material excellent at the VIII-year level. Number concepts were at Year VI.

The range on the Arthur was as great for Ray as it had been on the Stanford, while the patient's successes covered only two year levels. Ray worked more rapidly, profited by practice, and took in many more cues than did his brother. Probably the most interesting difference was shown in their attempts to work out the Kohs block designs. Although he used the right colors, the patient had difficulty in figuring out the shape of the square, for he first attempted to place the blocks in a row. After being shown how, he produced the right form but used only one color. Again he was corrected, and on the third attempt the square formation was conceived but all the reds were on one side and the blues on the other. At this stage he was able to perceive his error just as the time limit was reached. Finally on the fourth trial the solid color of the pattern was correct and the right colors were used in the mixed part of the design, but were not correctly placed in the pattern.

The patient's speech was greatly improved by this time; it was much more readily understood, and no interpretation was necessary. He was con-

siderably more active than he had been previously and was far more spontaneous. His reaction time still remained slow and his manner deliberate. In general, there was not a marked difference between the boys in their behavior, since the patient had become much more like Ray in his social adjustment.

In June of 1944, the patient's *IQ* was 85 on the Revised Stanford-Binet (*L*). His mental age was 10 years. Ray's rating at this time was *IQ* 111, mental age 13 years. Their test ranges were, respectively, from Year VI through Year XIII and from Year IX through Average Adult.

TABLE 1

Roy (the patient)	Ray
Memory and Retention	
In auditory recall, numbers through Year IX but sentences failed at Year VIII.	In auditory recall, through the IX-year level.
Visual recall adequate for bead chain at Year VI but not at Year XIII; design recall ot Year IX.	Visual recall, bead chain at Year XIII and all tasks below that level.
Paragraph memory passed at Year X.	Paragraph memory passed with the greatest of ease at Year X.
Language Usage	
Vocabulary, Year X.	Vocabulary, Year XII.
Abstract words, Year XII.	Abstract words, Year XIV.
Reasoning	
Poorest reasoning in situations requiring social intelligence; quite good in problem solving and detecting absurdities—this type of test passed through Year XI; no evidence of abstract reasoning seen.	Able to pass all types of reasoning problems through the XIV-year level, with the exception of ingenuities.
Generalization	
Managed to give similarities for three things at Year XI; similarities chosen were poor, however, and generalization inferior.	No difficulty with any items involving generalization up to the Average Adult level.
Spatial Relationships	
Drew diamonds well.	
Design recall at Year IX.	Recall of designs completely adequate although somewhat careless as to execution.
Binet paper-cutting* completely failed, and conception definitely unusual.	Binet paper-cutting* adequate at Year XIII; failed at Superior Adult III, but no bizarre placement of lines or cuts.
Field search showed excellent organization, was his best achievement. Able to interpret pictures as wholes through Year X.	Field search well organized. No difficulty in handling pictorial situations through Year XIV.

*Validation worked out in as yet unpublished manuscript.

The patient had a great deal of difficulty with the definitions and had to use his hands a great deal to express himself. Frequently he performed the act rather than defining it. Those tests requiring verbal manipulation which were about at his chronological age level were too hard for him, although Ray passed them easily. His speech, though improved, was still somewhat indistinct, and he had difficulty in pronouncing consonants. His nails were bitten to the quick; however, he showed no particular signs of anxiety in the test situation.

Ray was quick in expressing himself and was not at all shy, while the patient's shyness wore off in the course of the test. Physically Ray was still much smaller and more active than his brother, and succeeded in impressing one with his mischievousness.

The design and performance tests appealed particularly to the patient, even though Ray did them phenomenally well. The difference between their ratings was now far greater on the Arthur than on the Stanford, for the patient's *IQ* had dropped six points, to 82, with a mental age of 9 years 8 months, while Ray earned an *IQ* of 152 and a mental age of 17 years 9 months.

The patient's best performance on the Arthur was in the Porteus mazes. He had the greatest difficulty with the Healy picture completion and the Kohs block designs. The approach to the Kohs designs was again interesting. As before, patient tended to place the blocks in a line rather to form a square. Ray, on the other hand, had no difficulty with any of these tests, and completed correctly 14 block designs to his twin's seven.

On the Arthur Stencil Designs, patient's performance was markedly different from Ray's. Ray completed 18 of the designs and was quite ingenious in his approach. Patient, on the other hand, finished only 11 designs and had considerable difficulty in getting them correct. He had to go through a test in order to see whether it was right or wrong; if a single item were missing, he would be unable to make the small correction, and would have to take the whole design apart and begin again. He tended to cover up the cut designs with whole cards, and to use colors that were not needed. Moreover, he did not recognize completed card combinations. Ray showed none of this behavior.

Patient's relative slowness and deliberate manner of response were also apparent on the Hunt-Minnesota Test for Organic Brain Damage (3). He likewise made a great many more errors and in some instances was unable to do the task at all.

In school the boys were placed fairly appropriately for their mental age levels, but neither was working as well as might have been expected. At that time the patient, with a mental age of 10, was in the fifth grade. His reading comprehension would have placed him at a grade level of 3.3, and oral reading at 4.4. Arithmetical computation was similar for he earned a grade placement of 3.5.

Ray, mental age 13 years, was in the seventh grade. His reading and arithmetic were better than the patient's but were still definitely poor. His silent reading comprehension approached the fifth grade level, and arithmetical computation earned a grade placement of 5.2. Oral reading, however, reached only Grade 3.6. He did read aloud with more expression and better recall than did the patient. Both boys have continued to have reading difficulties.

Thus, in summarizing the test performances of the two boys, it would seem to us that the differences obtained on the various tests are greater than would have been expected from fraternal twins in general (2) and have tended to become greater with time. Neurological signs have disappeared, and at the present time the chief difference commented upon by the mother is that the patient is much slower than Ray, and has learned all motor activities more slowly. However, in spite of the fact that there are no definite neurological signs, the results on the tests seem to us to indicate some persistent neurological damage in the patient. This is apparent in his tendencies toward perseveration, in the very extreme slowness of his reactions, and in other characteristics of performance frequently seen in patients with brain damage. One observes, for example, his inflexibility, poor abstract reasoning, and poor generalization. Perhaps most notable is the difficulty with spatial visualization which runs through all of the patient's tests, and which is quite absent from Ray's. He has marked difficulty with concepts of shape, position, and color division. The distorted visualization may be brought out most clearly in the unusual production of the paper-cutting designs. The resulting product is like that seen in neurological cases, as shown in some research done in our clinics. Such responses do not seem to be based upon a simple inherited difference in intellectual capacity, but may probably be attributed to damage resulting from the lead encephalopathy.

References

1. Goldstein, K., & Scheerer, M. Abstract and concrete behavior: An experimental study with special tests. *Psychol. Monog.*, 1941, **53**, 1-149.
2. Haverfield, W. T., Bucy, P. C., & Elonen, A. S. The surgical treatment of lead encephalopathy. *J. Amer. Med. Assoc.*, 1940, **114**, 2432-37.
3. Hunt, H. F. A practical clinical test for organic brain damage. *J. Appl. Psychol.*, 1943, **27**, 375-386.

920 East 59th Street
Chicago 37, Illinois

The Journal of Genetic Psychology, 1947, 71, 195-199.

BEHAVIOR NOTES ON *C. CONICA*: ORIENTATION AND INDIVIDUAL DIFFERENCES*

Department of Psychology, Harvard University

F. L. Wells

It is easily observed though little recognized, that spiders resting with the body vertical, normally rest with head downward. There is scarcely another generalization that can be so broadly sustained with regard to these creatures, but it is specially evident with the orbweavers. To an experimental attitude there naturally occurs the question of what happens if the orb is inverted. Does the spider preserve its orientation with respect to the orb, or in respect to gravity? Except with very young spiders, it is rare indeed to find orbs in the field with which trial of this can be made; in some of these at least, reorientation is very prompt, following the orb as it is slowly rotated. In other cases the spider may remain in position, but change its orientation after some minutes (cf. the spontaneous return of *A. aurantia* after "shuttling"). Gravity is apparently the governing factor rather than anything intrinsic to the orb.

In the pursuit of this inquiry there were brought to the writer's house during May of 1938, several individuals of *C. conica*,[1] of which the present note concerns two. They are here known as Cc42 and Cc43, these being their serial numbers among the *conicas* systematically observed during that year, one in which the species was notably abundant. Cc42 had been placed in a specially made cage, with the intent that she should build an orb there, which could be rotated as desired. This she declined to do and escaped from the cage, but was subsequently found to have built a nest supported in part by a lace window curtain, in part by a bridge-lamp and a bookcase. Cc43 had been found in Hopkinton, Mass., in an orb wholly supported by a single small branch and its radiating twigs. This branch was removed and the entire nest secured in a laboratory standard by a clamp permitting 360° rotation. During the bulk of the present observations it was placed in close proximity to the nest of Cc42. On June 4, Cc43 had relocated

*Received in the Editorial Office on September 15, 1946.

[1]For a brief account of this species, cf. Comstock, J. H., The Spider Book: (Revised and edited by W. J. Gertsch). New York: Doubleday Doran, 1940. Pp. 465-467.)

its web elsewhere on the same branch; on June 6 at 1:30 A.M. (all times here cited, E. S. T.) the spider had abandoned this location and was seen at the top of the window-curtain, but later disappeared. Cc42 made no change of location, but was later released into a normal environment.

The orientational observations were necessarily confined to Cc43. At the time of collection (in Hopkinton, Mass., 5-29-38) the creature was perhaps ¾ grown. The supporting branch being cut, it was turned in the plane of the orb, and fixed at some 90° to its original position. The spider showed restlessness, remained unoriented for some two minutes, then left the orb-centre and perched on a supporting twig, as they often do when disturbed. When the assembly reached Newton the spider was not found, but at 9:15 the following morning the web had been rebuilt, with reoriented stabilimentum, the spider resting normally. At 1:02 P.M. the nest was inverted; the spider had made no move by 1:50. Various tuning fork stimulations were given, with no observed response, but at 1:55 she was found in normal orientation. At 8:23 the nest was again inverted; reorientation though not immediate was relatively prompt, having been accomplished at 8:35. There had again been failure of response to tuning fork stimulation, possibly a function of unusually low temperature at this time. At 7:00 P.M. the next day the nest was brought indoors, near to that of Cc42. It was again inverted the following day at 4:59 P.M. reorientation being observed at 6:15; again inverted there was no reorientation at 6:22, but it had occurred by 6:35. Reinverted, there had been no change at 7:15. At this time a vibrating fork being touched to the periphery of the web the spider made the usual seeking movement, and on return assumed reoriented position. Again inverted, normal orientation to gravity was resumed between 8:51 and 9:10. June 3, 7:50 P.M., the nest was turned through 90°, with no response. At 8:12 tuning fork stimulation as above, brought return to normal orientation, this time at right angles to the stabilimentum, which is now parallel to the substratum, instead of at right angles as normally. The nest was then returned to original position, bringing the spider's axis once more to 90° from the normal orientation. There was no change before 8:30, when the room was darkened for 15 minutes. At the end of this period the spider had begun rebuilding the nest, half the old structure being down. In addition to slow orientation observed, it is suggested that if any disturbance causes the spider to leave station while abnormally oriented, normal orientation will be resumed on return.

On June 5, beginning at 7:50 A.M., there was attempted systematic com-

parison of Cc42 and Cc43 in respect to response to a vibrating element approximated to the spider's dorsum, while in normal rest at orb-centre. The elements used were tuning forks of vibration rates 320 (large sized), 256 (medium), and 440 (small); also an electrically operated buzzer making far more noise, but of much slower rate. In tabulating the responses below, the forks are denoted by their vibration rates, the buzzer by *E*.

Typical orb-weavers' responses to this type of stimulation have already been described (cf. *Psyche,* 1936, 13, 10-13). In dealing with the small and frail *Cyclosas* the pattern of "seizing" had to be avoided, to obviate injury to the creature in detaching her from the fork. The category of "search" is substituted, denoting a seeking movement of the spider reactive to a vibratory stimulus, which causes her to leave the normal station at orb-center. It is normally to be looked on as a "constructive" seizure. To classify as "spread" or "reach," two legs at least, normally the hind pair, must remain in the normal resting position. The order in which the stimuli were given was reversed at each cycle of stimulation; the responses listed in Table 1.

TABLE 1

	Cc42				Cc43			
Time	*E*	320	256	440	*E*	320	256	440
7:50	0	spread	shake	shake	0	search	search	search
8:50	shake	shake	shake	shake	spread	shake	?	shake
9:25	0	shake	shake	shake	spread	spread	spread	spread
11:25	spread	shake	shake	shake	0	search	search	drop
12:25	shake shake	shake	shake	shake	0	spread	search	spread
1:25	0	shake	shake	shake	0	search	shake search	shake search
2:30	0	search shake	shake	shake	0	search	shake	search
3:40	0	shake	shake	shake	0	shake search	spread search	shake
4:35	0	shake	shake	shake	0	search	search	shift
5:45	spread	shake	shake	shake	0	search	search	search
6:55	0	shake	shake	shake	0	search	search	search
8:15	0	shake	shake	shake	0	search	search	search

In general may be noted the ineffectiveness of the buzzer. On the other hand, the essential similarity of the fork-reactions is evident, despite their disparities in pitch and volume. The dominant pattern in Cc42 is shake; in Cc43, search. Search is an aggressive response, shake a defensive one, supposed to have a function of frightening the intruder by a show of might; an archetype of "bluff." The (for this species) characteristic flight reaction

of "dropping" is practically absent; this can be attributed only to the abnormal indoor conditions.

On five other days there was, normally, a routine of observations utilizing the buzzer and a vibrating fork, successively approximating (*a*) the spider's *dorsum*, as above; (*b*) the venter, with web between; (*c*) touched to the periphery of the orb. This cycle of stimuli (with incidental additions) was given the first thing in the morning, around 6:00 A.M., before raising a dark windowshade; again an hour or more later, with daylight streaming in; again after dark with normal electric light. The buzzer was uniformly ineffective as a stimulus, as above, and is not included in the tabulation; neither are the variously pitched forks employed, sufficiently distinguished to make it relevant to separate them. In the field, the above tuning fork stimuli show with this species a characteristic diurnal variation of the response pattern, which is largely obscured in the present artificial surroundings. The responses are somewhat shifted towards the nocturnal type, and distributed as in Table 2.

TABLE 2

	Cc42			Cc43		
	Periphery	Dorsum	Venter	Periphery	Dorsum	Venter
Search	18	2	0	18	9	4
Spread	0	0	0	0	4	0
Shake	1	22	16	0	9	7
Drop	0	7	0	0	2	3
Other	0	0	0	0	2	3
Imperceptible	0	0	0	2	2	3
(Total "combined")	1	4	0	0	7	3

When the fork touches the web the search pattern is uniform here, as it is generally. In the dorsum and venter stimulations the preference of Cc42 for the shake response is again evident, the search pattern being nearly absent. In Cc43 the search pattern is relatively pronounced, and there is a greater variation in the response patterns as a whole. Among the "others" of Cc43 are three shuttlings; a pattern little observed outside *A. aurantia*. The excess of "imperceptibles" in Cc43 would denote a lesser irritability, despite a greater variability. The "combined" responses denote cases where for example an initial shake would be followed by a spread, a search, or a drop. These are listed separately in Table 2; they are some twice as frequent in Cc43.

Two other behavior aspects may be compared, concerning feeding patterns and nest building. As regards the feeding pattern, the critical points are

whether the food is approached promptly and spontaneously, or located by a tuning fork; what is the succession of biting and wrapping; where is the food eaten. The general situation is too abnormal for a criterion of field behavior, and is relevant only to differential response in these particular individuals. No difference in their feeding patterns could be made out; it was rare that the food was approached promptly and spontaneously, but this may result from its being already killed, thus not agitating the web. Additional relevance is thus lent to a uniform occurrence of biting before wrapping. There is a suggestion that a food insect so crushed that viscera are extruded, is less likely to be wrapped; occasionally the food was too heavy and bulky to be carried to orb-center, and it was naturally consumed at the point of capture.

During the periods of observation, seven new webs were built by Cc42, six by Cc43, the latter rebuilding about twice as often. The web of *C. conica* is normally marked by a stabilimentum consisting of a vertical line of insect skeletons, odds and ends that fall into the web, globular masses apparently the silk of old webs, etc. Usually the greater or entire length of the stabilimentum is below orb-centre, where the spider rests. This was the case with all but one of Cc42's constructions, with only two of Cc43's; in the other four the stabilimentum was wholly above orb-centre.

Thus, with respect to experimental stimulations, Cc43 showed a response-pattern habitually more variable and outgoing than Cc42; in nest-building there was similar departure from normal design, and an exploratory tendency that led to the creature's disappearance. These differences appear organismic in character, and their basis cannot well be other than innate. Among arthropods at least, one may without benefit of conditioning, be

"Either a little Liberal—Or else a little Conservatyve."

13 Holyoke Street
Cambridge, Massachusetts

The Journal of Genetic Psychology, 1947, 71, 201-222.

A BEHAVIORIST EXPLANATION OF CONCEPT FORMATION*

Institute for Research in Clinical and Child Psychology, Hunter College

LIVINGSTON WELCH

A. INTRODUCTION

One of the greatest challenges that has even been made to the Behaviorist is the demand for an explanation of *abstract concepts* in terms of stimulus and response. Obviously, this is impossible and therefore, Watsonian Behaviorism suffered unquestionable defeat. Today, however, the challenge of explaining abstract concepts can be met by a Behaviorist such as Hull, whose basic formula differs from that of Watson in two important respects. Hull, following in the tradition of Pavlov, deals with the stimulus as a pattern or configuration (2). Moreover, he makes use of the Pavlovian concept of *cortical trace*. In Hull's system this is known as an "afferent discharge." Present day Behaviorism can explain the formation and use of abstract concepts, if it considers them as derivatives of higher forms of generalization and makes use of a formula such as:
Stimulus configuration ⟶ Brain trace or afferent discharge ⟶ Response.

No one has ever seen a brain trace or an afferent discharge; still, its existence has been postulated by William James (1), Pavlov (5), Hull (2), and Köhler (3). This is really not a daring postulate, if we refrain from imagining its physiological structure. As I shall use this concept, the brain trace will mean simply this. When an organism is affected by a stimulus compound X so that it can be said to remember or recall X, some change in the organism's nervous system is responsible for this accomplishment. The organism after it perceived X is different from what it was before it perceived X, and such a difference seems to be essentially neurological. The neurological change, like the stimulus configuration, is presumably configural. When we speak of a configuration, we refer not only to parts of a whole, but also to their interrelations.

It often happens that we perceive a stimulus compound *abc*, but only recall *a* and *b* or *b* and *c*. For example, a man might perceive a woman in the street and at the time notice among other things, her brown hair. The next day, however, he may recall many details of this stimulus compound,

*Received in the Editorial Office on October 24, 1946.

but forget the *color* of her hair. The stimulus compound is a configuration of related characteristics of objects in the external world and the brain trace is the neurological counterpart of the stimulus compound, in so far as the latter is the cause of the former.

The *entire* brain trace configuration may fade or disappear, or several or many of its elements or all but one. Hence, the establishment or revival of that part of a brain trace configuration which corresponds to one characteristic of an object (e.g., pinkness), or to an integrated group of characteristics common to a certain class of objects, constitutes the basis of an abstract concept.

In order to avoid confusion it will be necessary to begin by explaining in detail what is meant by an abstract concept.

B. The Meaning of Abstractness

I shall describe a concrete impression or idea as one which refers to this or that specific pointable person, place, or thing. When we speak of this man, or the red color of this box, we are referring to a concrete entity in each case. On the other hand, when we talk of red boxes, we are referring to a class of objects and when we discuss the color red, or redness, we are referring to a quality that is thought of without any particular relationship to any particular thing. The human organism, only after many years of growth and training, is capable of thinking accurately in terms of classes and of characteristics divorced from any person, place, or thing (e.g., redness, justice). This capacity is called "abstract thinking." You can point at a member or the members of a class (i.e., at this or those cows), but you cannot point at the class itself (i.e., at the *class* of cows). Similarly, you can point at the red portion of a certain dress, but not at redness. The class of cows and redness do not exist in the perceivable world. These are abstract concepts.

There are varying degrees of abstractness. The more inclusive the class the more abstract the concept. The following examples are presented in their order of increasing abstractness:

CONCRETE	ABSTRACT
This dog	Collie . . . dog . . . animal . . . living substance . . . substance
This scarlet color	Scarlet . . . red . . . color . . . quality

We use the term *hierarchy* in referring to each level of abstractness. Let

us arrange one of the examples we have given in an order which permits each level of abstractness to be labeled.

THE CONCEPT	LEVELS OF ABSTRACTNESS
Substance	5th hierarchy
Living substance	4th hierarchy
Animal	3rd hierarchy
Dog	2nd hierarchy
Collie	1st hierarchy
This dog	*Concrete or object level*

The above order extends from the object level to the 5th hierarchy, and is a logical order which proceeds from the concrete to levels of *increasing* abstractness. The logician is concerned with this order alone, but the psychologist must also consider another one—the developmental order in which these abstract concepts are learned. In the logical order, the first class or concept of the 1st hierarchy is "collie," the concept of the 2nd hierarchy is "dog," and that of the 3rd hierarchy is "animal."

The reason why these concepts follow in such an order is because the first (e.g., collie) is included in the second (e.g., the class dog) which in turn is included in the third (e.g., the class animal), etc. One class is included in the other in such a manner by virtue of similarities. For example, though dogs and cats are dissimilar enough to be regarded as separate classes, they possess certain similarities which justify our thinking of them as one class—the class of animals.

The developmental order appears to be quite different. The child in learning a language may begin to use some of the words which are found at the second or third hierarchy level in the logical order. This does not necessarily imply that the child is using second or third hierarchy concepts, but rather that he is erroneously applying to concrete objects, a term used by the mature organism to designate classes at a higher level of abstractness. If the child has not grasped the fact that animals may be thought of as cats and as dogs, he will be using the class animal as a first hierarchy concept only. Unless he thinks of a class as including another class, he is not using a second hierarchy concept, and unless he thinks of a class which includes a class which in turn includes a class, he is not making use of a third hierarchy concept.

If dog is his first class concept then dogs, cats, cows and horses, in fact, all four-legged animals will be regarded by him as members of this class, while as yet, he will be unable to divide this class into sub-classes, such

as the class of dogs, cats, etc. The child will have comparatively little difficulty in learning other *1st hierarchy* concepts such as cat. He may have greater difficulty, however, in learning that dogs and cats belong to the class of animals. The relationship between the class of animals and the classes of dogs and cats is what is known as a genus-species relationship.[1] It appears to be quite simple, but it is really very complex. The child does not understand this relationship until he is aware of the fact that this thing over here is a dog and that other thing over there is a cat and that both are animals. To the undeveloped mind this seems to be a paradox or even a contradiction. If the child in his confusion could verbalize he might complain by saying:

> You call all of these things animals. That means they are the same. Then you turn around and call one a dog and another a cat. That means they are different. Why don't you make up your mind! Are they the same or are they different?

The answer is quite obvious! They are the same in some respects and that is why we think of them as a class of animals; still, they are different in other respects and that is why we think of them as dogs and cats. Things *can* be similar in some respects and different in others, but the task of considering their similarities one moment and their differences the next is much more difficult than considering the similarities without the differences. In other words, it is much simpler to think of things which are *either* dogs or cats under all circumstances, and never members of a more inclusive class, animals.

This genus-species relationship which involves both the similarities and the differences between objects makes it possible for us to construct the logical order we have discussed—that order in which we proceed from the concrete to levels of increasing abstractness. Let us see why this is true. In the logical order, we spoke of collie as a 1st hierarchy concept and of dog as a 2nd hierarchy concept. Now, dog is *not* a 2nd hierarchy concept, unless it is thought of as having species such as the class of collies, terriers, setters, etc. The 1st hierarchy concept is a class composed of this member, that member, and the other member. The 2nd hierarchy concept is a class that is composed of this class, that class, and the other class. The 3rd hierarchy concept is a class composed of this class, that class, and the other class, each of which has its own species or subclasses. Unless you are thinking of the class of *dogs* as a genus which has the species, collies, fox terriers,

[1]The class of animal is the genus which includes the classes dogs and cats which are the species.

grey-hounds, etc., you are not entertaining a 2nd hierarchy concept. Unless you are thinking of the class of animals, as a genus which has species such as dogs, cats, cows, etc., each of which in turn, is a genus which has its own species, you are not entertaining a 3rd hierarchy concept. There are so many ways of classifying and sub-dividing that it is impossible to establish any absolute hierarchical order. The examples given so far are arbitrary and presented as they have been for the purpose of illustration.

The phrase "abstract concept," at first sight, may strike the reader as being a little academic and far from the practical problems of psychology. This is not true, for even a moron is obliged to make use of some abstract concepts. If this same individual returns to the farm house after a visit to the barn and remarks "I fed the *animals* and just now, Bill says the crops this year aint goin to be what they was," he is at least thinking in terms of two 3rd hierarchy concepts—*animals* and *crops*. This ignorant farmer's boy not only knows the different classes of domestic animals, but also the species of each. He also can name the different types of crops (genus) and their species (e.g., crops include corn, etc.) and different sub-species (kinds of corn—Yellow Bantam, Country Gentleman, etc.)

As we have said before, there are two kinds of abstract concepts—those which represent the classes of objects and those which represent characteristics divorced from any object, such as color, justice, or number. The child is first obliged to learn this second type of abstract concept when he begins simple arithmetic. His introduction to arithmetic involves a certain amount of weaning. Just as he was once weaned from liquids to solids, he is now weaned from objects to abstract numerical quantities. Let us consider the stages of this slow process of learning. First, he is shown that two apples and two apples make four apples. At this stage he can be shown pictures of this little group of two apples which when put together with this other little group of apples make a large group of apples. The first little group is called two apples, the second little group is called two apples, and the large group is called four apples.

The slowness of his comprehension will be made manifest when he is called upon to generalize. Show him that two apples and two apples make four apples and then ask him how many goats he would have, if he were given two goats and then another two goats. Do not be surprised if he answers "four apples." The day will come, however, when he can solve this problem. As his arithmetical weaning continues, he will arrive at the stage which does not require the presence of apples or goats. He now can

find the sum of three and three by substituting his own finger in place of apples. When, eventually, he is completely weaned from objects he will be able to *think of three and three* as making the sum of six without having in mind, apples, goats, or even fingers. The numerical concepts, three and six, have thus become fully independent. They exist in this child's mind as entities separated and divorced from any specific object. This is truly a dramatic moment in the development of any human being, for he is now able to think of a characteristic in nature which he has never perceived nor will ever be able to perceive in isolation—an achievement which belongs only to the human race.[2] As he gains further knowledge of the various relationships of quantity, or in other words learns more arithmetic, he will come into more of his inheritance of human power, which include all of those achievements for which arithmetic and mathematics are essential.

One of the most important distinctions between simple and complex learning situations is that the former involve only impressions of specific objects or class concepts of a low order of abstractness (i.e., concepts of the 1st or 2nd hierarchy), while the latter involve concepts of a high order of abstractness. Before we are prepared, however, to discuss this distinction, we must study in detail how these abstract concepts are learned and examine the nature of their respective brain traces. This last point is particularly important, for in the past it was believed that even if the actual perception of a cow or a group of cows could establish a trace in the brain, certainly, the class of cows or the number 10 could not have a corresponding neurological change, since these entities, by themselves have not been perceived. If abstract concepts had no physiological counterparts, (i.e., brain traces) then there would be a sharp dichotomy between neurological activity and our abstract thinking. This would force us to abandon all hope of explaining, in scientific terms, how we learn abstract concepts, or to consider such learning as, partially dependent at least, on the function of the brain. The existence of the brain trace is an hypothesis and not a fact; still it is an hypothesis which is compatible with physiological inquiry.

C. Learning the Symbol of a First Hierarchy Object Class Concept

In a study made by Welch (7) it was found that the child in his early

[2]It is true, that an animal such as a rat may generalize. This might seem to indicate a knowledge of abstract concepts such as "triangularity," but no one has produced any evidence that these rodents can think of this particular characteristic (triangularity) divorced from a particular object.

years makes wide generalizations. This was particularly obvious at the linguistic level. As soon as he learns to associate a word symbol with one particular object, this same symbol will become associated, by virtue of generalization, with objects that are only remotely similar to the original object. Here is the foundation of a class concept. The word "chair" has become associated in a child's mind with a particular chair. The child has been trained to touch a certain chair every time the word "chair" is spoken. As a result, you have only to mention the word chair once and now the child runs over and touches it. If the child is brought into another room that has a rocking chair or even a stool, he will respond to the signal "chair" by touching the rocking chair or stool, because of their similarity to the original chair in the training situation.

The child thus indicates his understanding of the existence of the similarities between these objects which makes it possible to refer to all of them as "chair." He certainly will not be able to tell you why he associates the symbol with these objects that differ in so many respects. He has perceived certain elements common to all of them, but in the beginning of his linguistic development he has no way of analyzing these characteristics. Many years later, after he has learned a number of classes and classes within classes, he will become aware of the fact that he first associated the word chair with many different pieces of furniture, because they had four legs and were used to sit upon. He used classes long before he knew what classes were or why he used them. This fact reminds one of a poem written by George Santayana that begins "I *thought* before I learned to *think*, that bread and wine were food and drink." We have to do a great deal of thinking before we *"learn to think,"* because "learning to think" means attempting to discover why and how we think or learning ways and means of thinking more efficiently.

The problem of learning to associate one symbol with a class of objects is not very different from that of learning to associate two or more symbols with that same class. In a study made by Welch (6) with subjects ranging in age from 17 to 20 months, it required the same number of repetitions in order to associate each of two symbols with the same objects in the minds of his subjects. Being given two symbols for the same object did not confuse them or slow up their learning. They learned the two symbols in the same length of time it took them to learn one symbol for one object. We know of one child of two and a half years of age who had six different nicknames. Not only did she understand that all six applied to her, but she could explain

that her father called her the first, her mother called her the second, her grandfather called her the third, etc.

There is quite a difference between associating two symbols with the same class (e.g., "dog," "bowbow" to the class of dogs) and associating one symbol to one class, a second symbol to another class, and a third symbol to *both* classes (e.g., dogs, cats, and animals). In the first case we are dealing with synonyms, while in the second case we are dealing with the relationship of a genus to its species. The child can learn synonyms long before he can understand the relationship between a genus and its species.

D. Learning a Second Hierarchy Concept

How can we explain the structures of the brain traces corresponding to the class of animals and its species, dogs, cats, etc? The answer assumes a complexity in the structure of brain traces which may seem difficult to believe. If, however, our learning of class concepts involves any neurological changes, what right have we to assume that they *must* be simple? If the nervous system has nothing to do with such learning, why is it not independent of the development of the neurones and why should any injury to brain tissue affect it?

When the child learns to associate the symbol "dog" with the class of dogs, the stimulus compound involves not only the visual stimuli representing the appearance of the dog, but also the auditory stimulus, the word "dog." This learning, therefore, can be explained in terms of the adequate establishment of a brain trace whose elements correspond to the stimulus compound consisting of the appearance of a dog or dogs and the sound "dog." This brain trace must be of sufficient strength so that when the stimulus compound consisting of the sound "dog" *alone* is presented to the child, it will revive some or many of the elements of the brain trace representing the characteristics of the dog or dogs. In this very same way, the child learns to associate the symbol "cat" with the class of cats.

Now the symbol "dog" will not revive a clear, specific image in his mind as would the word "Fido," the name of his own pet. "Fido" has become associated with the visual characteristics of one specific dog's tail and one specific dog's head. The symbol "dog," however, has become associated with many different types of canine tails and many different types of canine heads. Hence, this symbol cannot revive a specific image. You may be able to draw a picture of your own dog from memory, but try and draw one of the *class* of dogs. This is impossible. You can only draw a

picture of that which you can perceive. The best you can do is to draw a picture of one *member* of a class, since a class cannot be perceived. The term "class" refers to a group of characteristics common to things which we can perceive. We can associate, however, symbols with these characteristics common to a group of perceivable objects. Just as the name "Fido" becomes associated with one specific image, so too, the word "dog" becomes associated with those characteristics common to all dogs.

So far we have discussed how we learn to associate a symbol with the image of one specific object and a symbol with the characteristics common to all objects of this class. In the first case we were dealing with a concrete object and in the second case with a 1st hierarchy concept or class. When we proceed to the learning of a second hierarchy concept we find that the process is the same. Just as the symbol of a 1st hierarchy concept becomes associated with the characteristics common to certain specific *concrete objects*, so too, the symbol of a 2nd hierarchy concept becomes associated with the characteristics common to certain *classes*. Obviously, as we proceed to 4th, 5th, 6th, etc., hierarchy concepts the characteristics common to the classes involved become fewer each time. The most inclusive class has the fewest characteristics common to its species.

Let us return to the subject of the 2nd hierarchy concept. What would be a proof that a child had learned a 2nd hierarchy concept, such as animal? A child has not really learned the 2nd hierarchy concept animal at the linguistic level, until he is able to associate the word symbol "animal" with a specific animal in a group which contains entities which are *not animals*. In addition he must be able to associate the word symbol of a species of animal (e.g., "dog") with a member of this species in a group which contains members of several different types of animal species (i.e., a group which contains a dog, a cat, a cow, etc.). Unless the child is able to make this second identification, he is using the concept animal as a 1st hierarchy concept. No one can use a concept, as if it belonged to the 2nd hierarchy, unless he has learned its species as well.

In Figure 1 an *over-simplified* diagram is given of the structures of the traces representing the concepts, cats, dogs, and animals. In order to make it easy for the reader to understand we have not used more than three characteristics for each object.

The auditory stimulus compound "dog" does not revive the trace of one stimulus compound, but it revives the elements of many traces of many different kinds of dogs of all shapes, sizes, and colors. The auditory stimu-

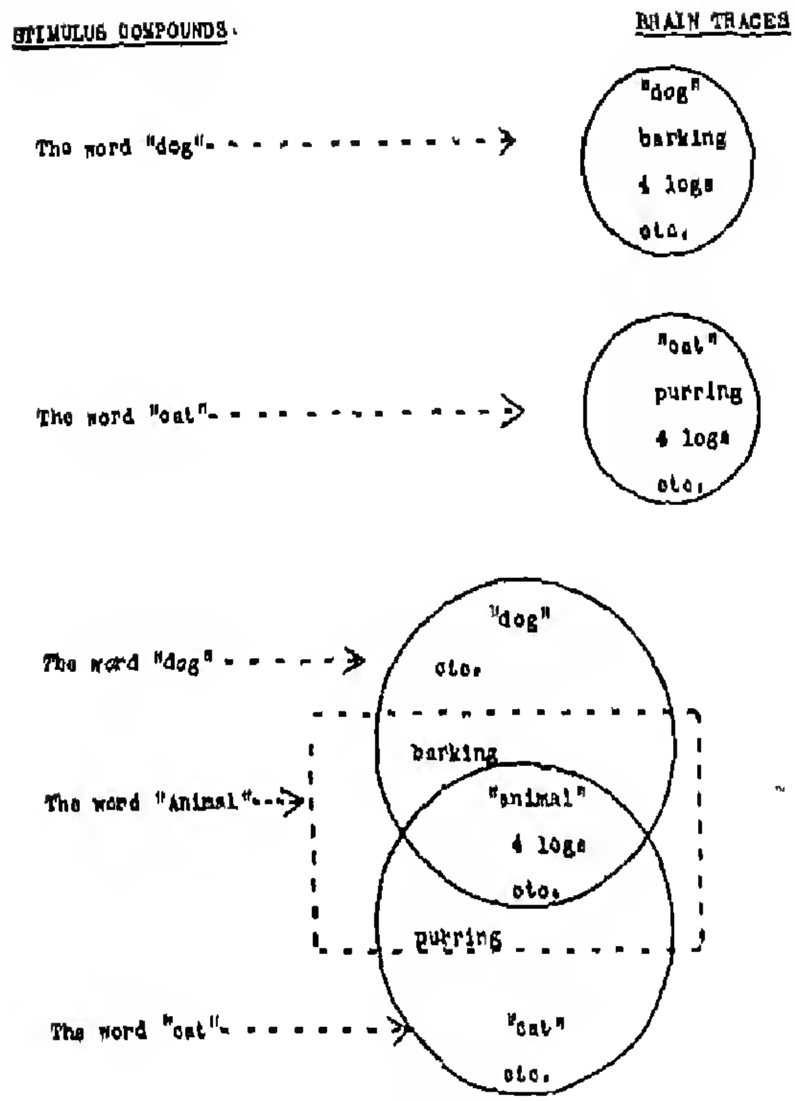


FIGURE 1
(Elements of brain trace configurations entering new combinations undergo changes. This is neurologically conceivable. See Hull (2) on the subject of neural interaction.)

lus compound "Fido" revives the trace which corresponds to a stimulus compound which includes the auditory stimulus "Fido" together with the visual, tactile, and auditory characteristics of a particular dog. The elements of these traces which this stimulus compound revives are elements common to all of these traces. The class concept dog is a configuration of these elements, a revivable totality which at the linguistic level includes that element which corresponds to its symbol (i.e., "dog"). The stimulus compound "cat" revives those elements common to many traces of many different kinds of cats. Many of the elements of the trace which represents the class of dogs are common to the trace which represents the class of cats. The stimulus compound "cat," however, does not revive the trace that repre-

sents the class of dogs, because of those elements common to dogs that are not common to cats.

At this point the 2nd hierarchy concept comes upon the scene. The stimulus compound "animal" revives the elements of many traces of many different classes of animals. The elements of these traces which the stimulus compound "animal" revives are elements common to all of these traces representing classes.

The bottom diagram in Figure 1 is a logical representation of the order of classes which is somewhat misleading but helpful from the point of view of simplicity. The square representing the class of animals, from the logicians standpoint should include all of the two circles, representing the species dog and cat and have plenty of spaces for other species. We have drawn this diagram differently so as to indicate that the stimulus compound "dog" will more readily revive the trace dog, than the trace animal, and that the stimulus compound "animal" will more readily revive the trace animal than the trace dog.

E. Experiments Concerning the Learning of Object Class Concepts

Obviously, it is more difficult to learn a 2nd hierarchy concept than a 1st hierarchy concept and still more difficult to learn a 3rd hierarchy concept. But when, may we ask, can this type of abstract knowledge be taught? Unfortunately, the data on this subject are somewhat inadequate. Welch (6) gave an identification and questionnaire test to 93 children ranging in age from 21 to 72 months. In the first part of the test, these subjects were required to identify specific objects such as an apple, a man, a shoe, etc. When this was done they were called upon to identify classes of the 1st hierarchy, such as the class of fruits, the class of people, the class of clothes, etc. This was accomplished by telling the child to "put only the fruit over here in the corner." He was not given credit for knowledge of this class unless all of the fruits were included and all of the non-fruits were excluded. Lastly, he was called upon to identify classes of the 2nd hierarchy, such as the class of food, which included both fruits and vegetables.

The questionnaire test consisted of 14 questions, such as "What kind of boats do you like? What kind of toys do you like? What kind of flowers do you like?" etc. If, in answering any of these questions, the child mentioned one or two of the correct species, such as "I like sail-boats" or "I like balloons," he was given credit for knowledge of one concept of the first hierarchy.

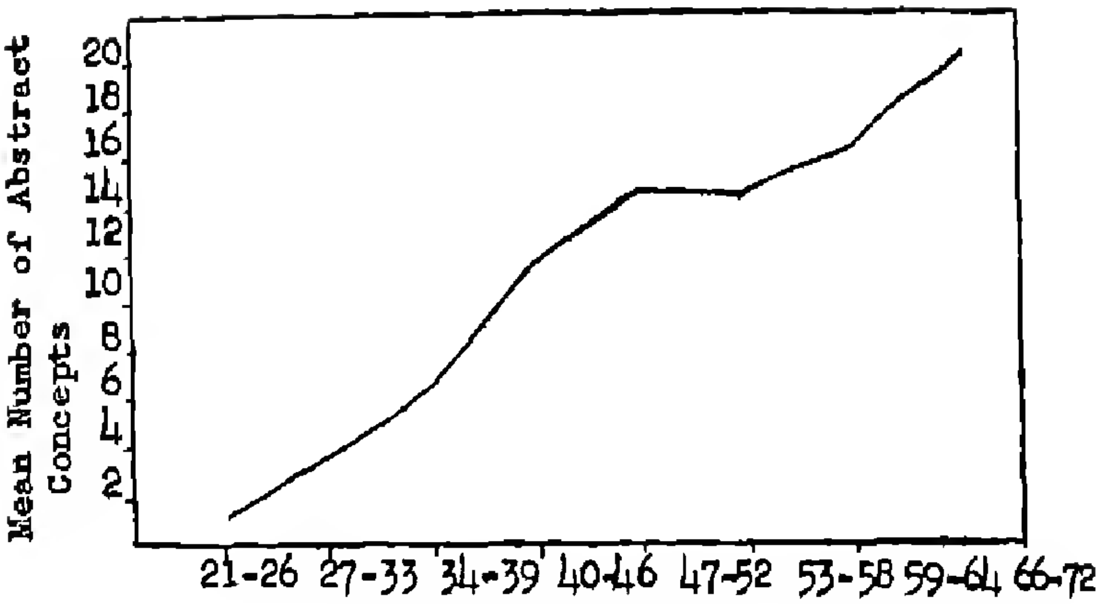


FIGURE 2
(From Welch, 7)

In order to make a perfect score on this test the child had to identify 21 1st hierarchy concepts and three 2nd hierarchy concepts. In Figure 2 we have presented a graph of the identification of 1st hierarchy concepts. None of the children below 34 months identified any of the 2nd hierarchy concepts and only three out of 10 between the ages of 65 and 72 months identified all three of them. The greatest gain in learning 1st hierarchy concepts as indicated by this test seems to be between the 34-39-month level and the 40-46-month level. It is at this period that Smith (6), McCarthy (4) and others have found the greatest gain in general vocabulary. In comparing this study in abstract vocabulary with those of general vocabulary, it is interesting to note that the child of six years of age who has a general vocabulary of well over 2,000 words, probably does not understand or use more than two dozen 2nd hierarchy concepts. Concepts of the third and fourth hierarchy he does not usually grasp until the ninth or tenth year. This is significant when you stop to think of how many 2nd hierarchy concepts you use in your daily conversation and how difficult it would be to express yourself without them. In college the main structure of knowledge in such subjects as minerology, or botany consists of hierarchical systems of at least five or six levels.

In another study by Welch (8) an attempt was made to determine the readiness with which young children learned concepts of different levels of abstractness. Artificial concepts were used in training them so that one

child by prior teaching would not have an advantage of another. Sixty-four subjects from 36 months to 18 years of age were taught to associate letters with the blocks found in Figure 82. Observe that "R" is the class name for the blocks A and B, X the class name for the blocks C and F, T the class name for the blocks H and K, and Q is the class name for the blocks O and L. R, X, T, and Q are all 1st hierarchy concepts. W and Z are the names of 2nd hierarchy concepts, while J is the name of the one and only 3rd hierarchy concept. When some of these children learned to identify correctly the R and X classes and their respective members (i.e., A, B, and C, F) and were then trained to identify the W class, this additional training either completely confused them, so that they could not make any correct identifications, or else they treated W (a 2nd hierarchy concept) as though it were a 1st hierarchy concept. In other words they telescoped the entire 2nd hierarchy structure down to the 1st hierarchy level. When asked for the 2nd hierarchy class W, they picked up the blocks, A, B, C, and F which was correct. They picked up the correct individual block each time its name was mentioned. But they responded to the command "pick up R or pick up X," as if both of these were synonyms for W. That is to say, every time A or X was asked for, they picked up all of the blocks. This gives us some indication of the difficulties which the child experiences in learning to mount upward to concepts of increasing degrees of abstraction. It illustrates two of the types of failures he may make in his pursuit (i.e., becoming completely confused with all that he has previously learned before and telescoping a higher structure to a lower level).

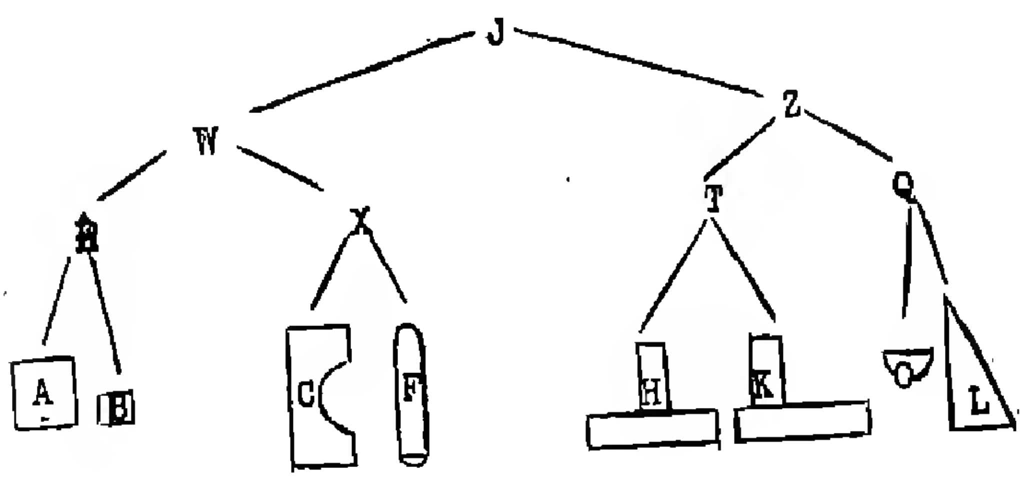


FIGURE 3
(From Welch, 7)

F. Vertical and Horizontal Conceptual Development

When we were discussing the progression from the least inclusive to the most inclusive class (i.e., Collie—dog—Animal—Living Substance—Substances), we were referring to a vertical progression or development. Conceptual thinking, however, involves another progression or development, the horizontal. Let us give an example of horizontal progression taken from our every day experiences. If we hold before you a certain red rectangular object and ask you what it is, you will call it a brick and explain that it is one of the many kinds of building material. This object belongs to the class of bricks (a 1st hierarchy concept) and the class of bricks along with the class of lumber, etc., belongs to the class of building material (a 2nd hierarchy concept). Such identification may be found in one situation and not in another. Suppose that we turn to a riot situation where sticks and stone are being hurled. It is perfectly correct to speak and to think of this same red object as a missile (a 1st hierarchy concept) which belongs to the class of weapons (a 2nd hierarchy concept). In a third situation your friend may tell you to put the door-stop in front of the door and when you look in the direction in which he is pointing you perceive that same red rectangular object, which is one situation you called a brick and in another a missile. If this object is a doorstop, then it must be thought of as a piece of furniture. Let us summarize this progression (Figure 4).

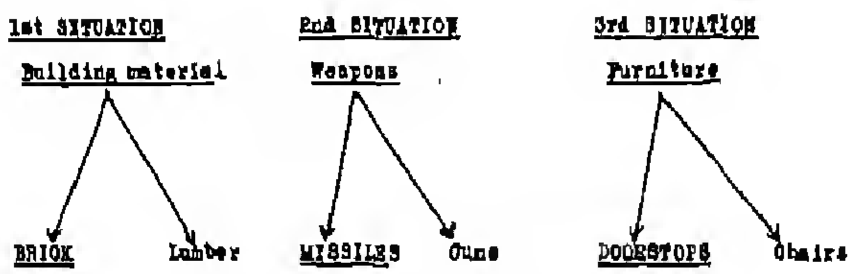
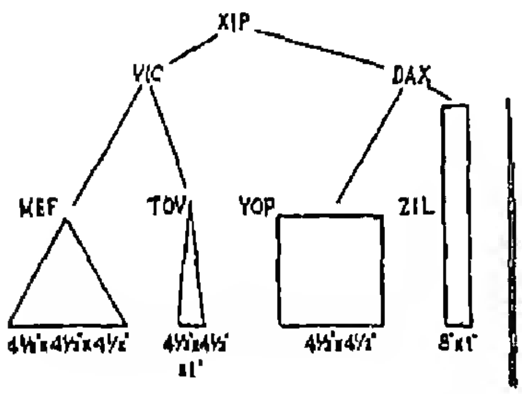


FIGURE 4

To what class does this red rectangular object belong. Is it a brick, a missile, or a doorstop? It may be any one of these things depending on the situation. At first this may appear very confusing, but realize that this is the way in which you have been identifying many objects most of your life and such horizontal progression or development is not confusing, but helpful and necessary. You would find it confusing and embarrassing if you were *unable* to make this progression. Do you remember the child of two and a half years of age who had six names? The child not only

realized that all six applied to her, but she also knew the six authors of each of these names. Similarly, you know three names for this red rectangular object, and you also know the type of situation in which each of these three names or classes is applied.

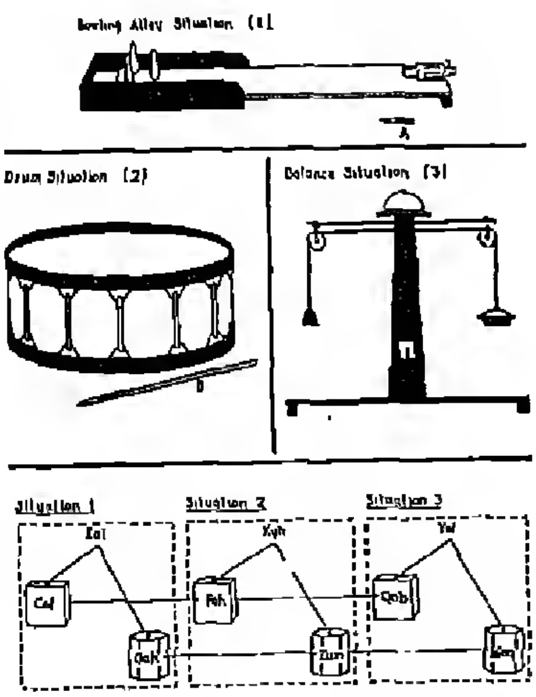
The child learned her six names before she was able to entertain a 2nd hierarchy concept. Horizontal development appears before vertical development. This was shown by a study made by Welch and Long (9, 10). In this experiment two different types of training were given to a large group of children ranging in age from 66 to 83 months. One involved vertical and the other horizontal training. The material and the names of the class concepts used in the vertical training are presented in Figure 5. The material and names of the class concepts used in the horizontal training are



Vertical training situation.

(From Welch, Long) (10)

FIGURE 5



Horizontal training situations

(From Welch, Long) (10)

FIGURE 6

presented in Figure 6. The first is very similar to the vertical training in the Welch experiment (see Figure 3). The second involves three situations comparable to those which we discussed in connection with the red rectangular object. In this experimental training situation we have two objects, a cube and a block with six sides. The first situation is a bowling alley situation. Here, the cube and block with six sides are used as ammunition. A pin is inserted into both objects and they are shot out of the gun so as to knock down the tenpins. In this situation the child is taught that one of these blocks is a *CEF* and the other a *GAH*, while both are *XAT*. (Such classification is similar to the following: This is a brick, that is a piece of lumber, while both are building materials). The second situation is a drum beating situation. The two blocks are therefore given different names. The *CEF* is now a *FEH*, the *GAH* is a *ZUM* and instead of belonging to the class of *XAT*, they belong to the class of *KUH* (just as the brick shifted from the class of building material to the class of weapons). The function of the block in the second situation is quite different from what it was in the first. Before the child beats the drum he sticks one block at a time on to the end of the drum-stick. Instead of being bullets, as they were formerly, they are drumstick tips. In the third situation, these drumstick points become weights. When one or both are placed on the tray found to the right of the apparatus, the tray descends and causes the bell to ring. For the second time their individual names and class name have been changed. The *FEH* has become a *QOB*, the *ZUM* a *MEQ*, and the Class *KUH* has changed to the class *YOF*. The method of teaching the child the different names and classes in the horizontal situations was the same as in the vertical situation.

It was found that horizontal training was easier for the children than was the vertical. This is particularly interesting when you stop to consider that in the vertical situation the child has only seven concepts to learn, while in the horizontal he has nine. As you see, the quantitative difference is not as significant as the qualitative difference. Note, furthermore, that the child has only two levels to learn in the vertical test comparison with three different situations in the horizontal test. Not only this, but the equilateral triangle in the vertical situation never changes its name *MEF*, while in the horizontal situation the cube is given one name in one situation and another name in another situation. Learning a different name for the same object in three different situations is confusing, but not as difficult as learning the position of an object in a 2nd hierarchy structure. Three steps in the

horizontal direction (e.g., going from situations one to two to three) are easier than two steps in the vertical direction (i.e., proceeding up to the 2nd hierarchy from the concrete level).

The striking difference in the difficulty of the various levels of vertical progression are made apparent in this same experiment. "In a study of the vertical process, 13 children failed the 1st hierarchy test because they never correctly identified the class concept, although 69 per cent of their identifications of the species of the class concept were correct" (10). In simpler language, these children learned the names of the individual blocks almost immediately. When asked for the *MEF* they picked up the equilateral triangle and when asked for *TOV* they picked up the isosceles triangle, but even after as many as 40 corrections they showed no signs of having learned that the symbol *VIC* pertained to both, that *VIC* was the class of triangles and that they should therefore pick up both.

The reasons for this difference in learning the name of a thing and learning the name of its class have already been explained. When you learn to associate the name *FIDO* with the visual appearance of your own dog, the sound has become integrated with a pattern of visual characteristics which could even be photographed. When, however, you learn to associate the word *DOG* with the class of dogs, this sound becomes associated with the elements common to all dogs (a configuration which could not be photographed). This is a more difficult brain trace to establish. Similarly, learning the name of the equilateral triangle (i.e., *MEF*) is easier than learning the class name *VIC*. This class name must become associated with several or many elements common to two different brain traces corresponding to two different triangles.

This type of learning, however, is only difficult for the child when species are involved. We have seen on many occasions, that when he has learned to associate a word with one object, this word by virtue of the process of generalization will become associated with objects that are only remotely similar to the original object. Let us observe the transition from this simple generalization to the stage at which a genus-species relationship is involved. We shall say that (*ab*) represents the characteristics of a dog. When the child learns the word "dog" this auditory stimulus becomes integrated with the characteristics (*ab*).

STIMULUS COMPOUND BRAIN TRACE
"dog"-(ab) the dog's characteristics establishes ——> ("DOG"-AB)

When now he sees a cat which is somewhat similar to a dog in so far as it has four legs, moves, etc., the visual characteristics of the cat (*ax*) revive the brain trace ("DOG"-AB). This is an example of a very wide generalization.

STIMULUS COMPOUND BRAIN TRACE
(ax) —————— revives ——————> ("DOG"-AB)

As the child's training continues, he is taught that this second object is a cat:—

STIMULUS COMPOUND BRAIN TRACE
"cat"-(ax) —————— establishes ——————> ("CAT"-AX)

Hence, the stimulus compound (*ax*) no longer revives the trace ("DOG"-AB)., but instead the trace ("CAT"-AX). In the final stage of this learning, he must be taught to associate the word "animal" with, at least, those characteristics common to dogs, cats, etc. We can express this learning in the following over-simplified manner:—

STIMULUS COMPOUND BRAIN TRACE
"Animal" —————— elicits ——————> ("ANIMAL"-A)
(A) = the characteristics common to all animals

OR:—

(ab-ax) —————— elicits ——————> ("ANIMAL"-A)

When the stimulus compound (*ax*) at first revived the brain trace ("DOG"-AB), this stimulus compound revived the trace of a photographable object, the original object which has become associated with the word "dog." Such behavior is not too far beyond the limits of mere faulty or careless perception (i.e., mistaking the cat for a dog). When, however, the child has learned to associate correctly the symbol "animal" with the class animal, this symbol must be associated with that unphotographable configuration composed of common elements of many different animals. This type of behavior is very different from that involved in his first generalization, where the stimulus compound (ax), the appearance of the cat, revived the brain trace ("DOG"-AB). It is not only different but obviously more difficult. The reasons for this additional difficulty we shall discuss presently.

G. Learning Quality Concepts

We described the symbol of a 2nd hierarchy object class concept as being associated with a configuration composed of the common elements of many different brain traces. The symbol of a quality concept is associated with a more restricted configuration composed of one specific quality or element common to many traces (e.g., elements corresponding to the stimulus characteristic scarlet) or a specific type of quality or element common to many traces (e.g., elements corresponding to that stimulus characteristic red or the color of the object). This is a little difficult to understand, or more precisely it is very easy to misunderstand. When you hear someone say "red" or "redness" you may think of a red patch or a red circle—still, the *quality* red is *not* a patch or a circle. Patches and circles are objects, not qualities. When you hear the word "animal," you think of a pig, but the class animal is not a pig. A pig is but one member of this class.

When you hear the word "red" this stimulus compound revives in your brain certain elements of different characteristics which correspond to different reds of different objects you have perceived. This revival may be expressed as indicated in Figure 7. This particular stimulus compound, the

<u>STIMULUS COMPOUND</u> <u>BRAIN TRACES</u>

(SCARLET ~~rectangular box~~
"red" ----------> (PINK, ~~long-sleeved dress~~
(CRIMSON, ~~triangular flag~~
(VERMILLION, ~~small book~~
(CRIMSON, ~~billiard ball~~

FIGURE 7

word "red" revives a configuration which is composed of many such specific elements corresponding to the characteristics of different types of color that have been perceived in different stimulus compounds. To make it easier for the reader to understand, we have crossed out all of the other elements, so that the different kinds of red stand out alone. The total configuration of the trace of the quality red is composed of all of these elements together with an element which corresponds to the auditory stimulus, the word "red."

It is impossible to have a mental picture of such a concept as red, for like the concept of a class of objects, *it cannot be pictured*. When the stimulus compound revives the brain trace elements corresponding to different

types of red, the result is not an image which is a blending of all of these shades of red. If you consciously attempt to think of red or redness, no color comes to your mind, but images of red objects may immediately follow. Many other phenomena to which redness is related are readily revived. The brain trace which represents the concept red or redness is of this sort. Some psychologists might consider the revival of an abstract concept as an example of imageless thought. The object class or the quality itself is imageless, for the reasons already given, but when we revive such traces we may revive the image of their respective symbols. When you hear the word animal, you may have an image in your mind of the word "animal" or when given the problem "How much is 6×6?" the image of the printed symbol *36* may come to you.

We have already seen that qualities can be divided into classes (e.g., Scarlet—Red—Color—Quality). Just as we learn to associate a symbol such as the word "red" with different types of red that we perceive, so too, we learn to associate the word "scarlet" with that characteristic common to many objects which are scarlet. Here, the stimulus compound the word "scarlet" revives a configuration which is composed of many elements of different brain traces corresponding to the characteristic "scarlet" (which in turn is common to different stimulus compounds). This configuration is a brain trace itself which, at the linguistic level, includes elements which correspond to the auditory stimulus "scarlet." The trace red only differs from the trace scarlet in so far as the former is a configuration of a greater variety of elements that have been combined from the traces of perceived objects (i.e., elements representing different kinds of red).

In arithmetic and mathematics, the complexity of the traces that are established and revised is far greater. Our arithmetical knowledge of the number 4 which includes all that this symbol implies, must among other relationships include those indicated in Figure 8. Every one of these num-

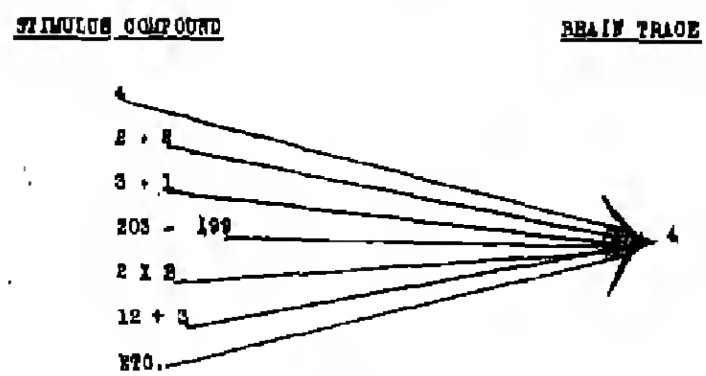


FIGURE 8

bers has its own particular trace. This is also true of each arithmetical symbol (e.g., x, —, +, ÷, etc.). When you perceive the stimulus compound 4, it immediately revives the brain trace 4. When, however, you perceive the trace *1,096 divided by 274,* this does *not* immediately revive the trace 4. It revives first the traces corresponding to the symbols, 1,096, "divided by," and 274, respectively. Such a stimulus compound will elicit the behavior (indicated by the division symbol) of dividing one number into the other. The solution of this problem or the conclusion of this arithmetical behavior will be the revival of the brain trace representing the concept 4. The whole constitution of any numerical concept involves these intricate relationships. A child in first grade will not have in mind the trace corresponding to 4 that you are capable of reviving in your mind, unless 4 to him means 2 + 2, 5 — 1, 1,096 ÷ 274, etc. If such stimulus compounds do not indirectly revive that quantity concept represented by the symbol 4, then either he has a very inadequate understanding of this concept or of the other numerical concepts represented in the above mentioned stimulus compounds. In other words, their corresponding brain traces have not been adequately established, or else they do not include a sufficient number of elements corresponding to all of the required arithmetical relationships.

H. Summary

I have attempted to show that the establishment and use of abstract ideas can be explained in Behavioristic terms. This is not possible, if we start with Watson's formula:—Stimulus—Response. It can be done, however, if we make use of a formula such as Hull's which includes postulated brain traces and describes the stimulus as a configuration. The stimulus is a configuration and it is hardly possible to account for the facts unless we assume that its effect, on the nervous system or the brain trace which it produces, is also configural. Hence, each characteristic and relationship which goes to make up the stimulus compound or configuration, would then have its counterpart in the brain trace configuration. We must also assume that one or many elements of the brain trace configuration may fade or become extinct, while one or many persist in the sense that under certain conditions they may be revived.

I have described two types of abstract phenomena—classes of things and qualities or characteristics divorced from any specific object (e.g., redness). Both types I have treated as derivatives of higher forms of generalization.

References

1. HULL, C. L. Principles of Behavior. New York: D. Appleton-Century, 1943.
2. JAMES, W. Principles of Psychology. New York: Holt, 1890.
3. KÖHLER, W. Gestalt Psychology. New York: Liveright, 1929.
4. MCCARTHY, D. The Language Development of the Preschool Child. Minneapolis: Univ. Minnesota Press, 1930.
5. PAVLOV, I. P. Conditioned Reflexes. Oxford: Oxford Univ. Press, 1927.
6. SMITH, M. E. An investigation of the development of the sentence and the extent of vocabulary in young children. *Univ. Iowa Stud. Child Wel.*, 1926, **3**, No. 5.
7. WELCH, L. A preliminary investigation of some aspects of the hierarchical development of concepts. *J. Genet. Psychol.*, 1940, **56**, 359-378.
8. ———. The genetic development of the associational structures of abstract thinking. *J. Genet. Psychol.*, 1940, **56**, 175-206.
9. WELCH, L., & LONG, L. The higher structural phases of concept formation of children. *J. of Psychol.*, 1940, **9**, 59-95.
10. ———. A further investigation of the higher structural phases of concept formation. *J. of Psychol.*, 1940, **10**, 211-220.

Institute for Research in Clinical and Child Psychology
Hunter College
695 Park Avenue
New York City

The Journal of Genetic Psychology, 1947, 71, 223-251

THE TRANSITION FROM SIMPLE TO COMPLEX FORMS OF LEARNING*

Institute for Research in Clinical and Child Psychology, Hunter College

LIVINGSTON WELCH

INTRODUCTION

Instead of attempting to distinguish between reasoning and problem solving, we shall examine a series of situations which will require forms of learning that increase in complexity. Textbook writers might describe some of these as problem solving situations and others as reasoning situations, but at times there are advantages to be gained by ignoring this dichotomy. We will begin with the principle that as we proceed from simple to more complex forms of learning, there are required (*a*) an increase in the efficiency of the *interactivities* of the following mental processes: perception, memory, recall, generalization, association, and the recombination of ideas; (*b*) a greater number of these interactivities occurring simultaneously or consecutively and; (*c*) factors pertaining to conditioning, trial and error, insight, imitation, and practice.

In analyzing a series of problems of increasing complexity, we shall in each instance study the factors which pertain to both the environment and to the organism. The first (factors pertaining to the environment) concern the stimulus configurations of these learning situations, while the second (factors pertaining to the organism), relate to the manner in which the organism must respond to the learning situation. Let us first classify all of the factors before analyzing the first of these learning situations (Figure 1).

PROBLEMS 1 AND 2: THE INCREASE IN COMPLEXITY IS EXPLAINED IN TERMS OF AN INCREASE IN PERCEPTUAL DIFFICULTY

According to the law of *Similarity*, formulated by the Gestalt psychologists, phenomena in the perceptual field that have similar characteristics are more likely to emerge as one single stimulus compound than those whose characteristics are less similar.

In many learning or problem situations it is essential that only one object, or part of an object emerge from the ground. If, in the subject's visual

*Received in the Editorial Office on October 24, 1946.

THE TRANSITION FROM THE SIMPLER TO THE HIGHER FORMS OF LEARNING INVOLVES

THE ENVIRONMENT

1. FACTORS DIRECTLY INFLUENCING THE EMERGENCY OF THE FIGURE FROM THE GROUND.
   - A. WITH REFERENCE TO THE LAWS OF
     1. Similarity, 2, proximity, 3, continuity, 4, inclusiveness, 5, pregnanz.
     2. The amount of data in the visual field.
   - B. WITH REFERENCE TO THE MEDIA
     1. Three dimensional material
     2. Pictorial material
     3. Language
        - i. Concrete and abstract,
        - ii. Non ambiguous and ambiguous,
2. THE CONDITIONS OF LEARNING AND THE TIME ELEMENT.
   - A. Conditioning, trial and error, insight, practice, imitation,
   - B. Time required and the consecutive steps needed.

THE ORGANISM

3. THE NUMBER AND EFFICIENCY OF THE MENTAL PROCESSES REQUIRED.
   - A. An increase in the efficiency of the inter-activities of the mental processes.
   - B. A greater number of those interactivities, occurring simultaneously or consecutively.
4. MOTIVATIONAL FACTORS

FIGURE 1

field, there are many objects which are very similar in all respects, it will be difficult for the essential object to emerge from the ground, or in other words be perceived. As the law of similarity states, these phenomena, because of their similar characteristics are more likely to emerge as one single stimulus configuration. Therefore, in any learning situation which involves discrimination, the more similarity between the objects in the visual field, the more difficult will this discrimination be.

Problem 1

In a study made by Welch (6) on a group of four children between the ages of 16 and 24 months, calibrated material was used to detect improve-

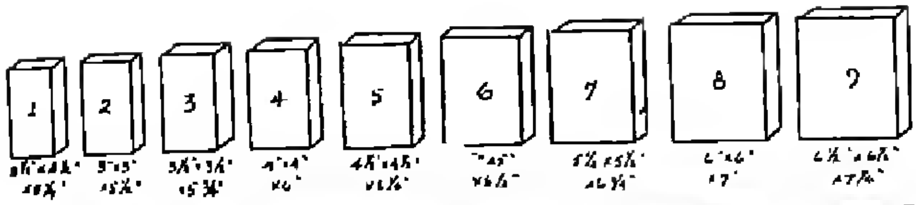


FIGURE 2

ment in discriminatory performance (see Figure 2). During the training period, candy was hidden under Box 1 and the child was taught to knock it over to obtain his reward. In the test, Box 1 was first placed along-side of Box 9. The positions of the boxes were changed in random order from trial to trial. If the child succeeded 9 times out of 10 in choosing Box 1, he was tested with Box 1 and Box 8. The most difficult in this series was discriminating between Box 1 and Box 2. Obviously, *learning becomes more difficult as the similarity between the pairs of boxes increases.*

Problem 2

In this same study a second series of discrimination tests was run. The same subjects, the same material, and criteria of success were used. The second series differed from the first only in the method of training prior to the test period.

In Problem 1 the child was taught always to knock over Box 1.

In Problem 2 he was induced to put his candy in either the larger or the smaller box. As soon as this was done the candy was rattled in the box for several seconds as he watched it. The box then was set up with the other member of the pair behind a screen and in about three seconds, they were shown to the subject. The child was in search of his candy. In this test he was obliged to remember the box in which he had placed it.

The results of both tests are given in Table 1.

TABLE 1

Subjects	Problem 1 Age in months	Problem 1 Boxes discriminated	Problem 2 Age in months	Problem 2 Boxes discriminated
1	23	1-2	24	1-7
2	21	1-2	25	1-5
3	22	1-3	24	None
4	19	1-3	25	None

Obviously, these children did much better on the first problem than on the second. They were taught first to solve Problem 1, hence, what is known

as negative transference had some effect on their performance on the second test. That is to say, in the first problem they were taught always to knock over the small box, a habit which they carried over to the second problem. This was overcome, however, by discontinuing the first test and training them for several months on the second test.

As the results indicate, two of these children understood readily what was expected of them in Problem 2; still, one of these was not able to discriminate Box 1 from Box 6, while another was not able to discriminate Box 1 from Box 4, though these last two subjects had been able to discriminate Box 1 from Box 2 in Problem 1.

Let us analyze the mental processes required in both problems. We shall discuss in particular, perceiving and memorizing. In the training period of the first problem, the child learned to associate candy with the smallest box (i.e., to associate it always with Box 1). This situation was very much like an orthodox conditioning situation. The essential stimulus compound contained the visual characteristics of the *candy and the Box 1 over-turned.* During the training period, this stimulus compound was presented many times, restrengthening the integration or association between candy and the smallest box. During all of the trials of Problem 1 this integration was restrengthened, both positively and negatively. When the child turned over the smallest box he received candy, and when he turned over another of the others he was not rewarded at all.

In Problem 2, the tax on his process of memorizing was very much greater. The candy was not associated with one box alone. Sometimes it was in the larger and sometimes it was in the smaller box. The integration or association between the appearance of candy and the box that contained it on any trial lasted for a period of no more than 20 seconds. It occurred at the time that the child placed his candy in the box and watched it roll around. On the next trial, however, he was obliged to place it in a *different box.* Instead of building up an association between candy and one box, as in the first problem, the child had to associate candy with two different boxes presented at random by the experimenter from trial to trial.

A comparison of the results of Problems 1 and 2 show us that the mental processes of memorizing and perceiving are the most important to observe. When memorizing is strengthened by frequent repetitions of a stimulus compound that is the integration of *the visual characteristics of candy and the same Box 1* then the child is able to perceive very fine differences, as between Boxes 1 and 2. This occurred in Problem 1. On the other hand,

when memorizing is not thus restrengthened, then at best, the child is only able to perceive differences that are much more obvious (e.g., the differences between Boxes 1 and 7, or 1 and 5). This occurred in Problem 2.

In both problems we see how the processes of perceiving and memorizing (*A*) must function simultaneously. *Throughout the training and test periods, the subject must perceive and memorize and recall. The more the processes of memorizing or recalling is taxed, or the less that it is restrengthened, the less efficient will be the process of perceiving* (i.e., the subject will not be able to make such fine discriminations).

In both problems, many elements of the conditions of learning, conditioning, and trial and error may be found. There is little to be gained, however, by trying to estimate how much there is of one or how little there is of the other.[1]

Problems 3 and 4 (Increase in Complexity of the Learning Situation is Explained in Terms of (*A*) the Introduction of Linguistic Instructions and (*B*) an Increase in Perceptual Difficulty)

The next problems to be considered are taken from a series of inductive reasoning tests constructed by Long and Welch (24). *Problem 3* is the simplest in this series. The subject is required to discover what kind of a block makes the lights of the apparatus (see Figure 3) go on. A telephone plug is attached to each of the blocks. These plugs fit into holes or jacks, as they are called. The plug of only one kind of a block in each of these tests makes the light go on. In Figure 85 a sample trial is given of the simplest of these tests. The plug of the camel block is inserted in the jack opposite the higher light bulb and the light goes on. The subject is now asked—"which of the three blocks at the left will make the bottom light go on?" Only the camel block will do this. The inference should be that, if in one instance the camel block made the light go on, it will make it go on in another. As the test proceeds, he will discover through trial and error that whenever by accident he chooses the same block that made the higher light go on, this type of block makes the lower light go on (Figure 4).

Let us now compare Problem 2 with Problem 3. The latter is much more difficult. Problem 1 can be presented without verbal instructions. Here the child is in quest of candy which is shown to him. His appetite

[1]Recalling is also involved, but its omission from the discussion makes our analysis easier to understand.

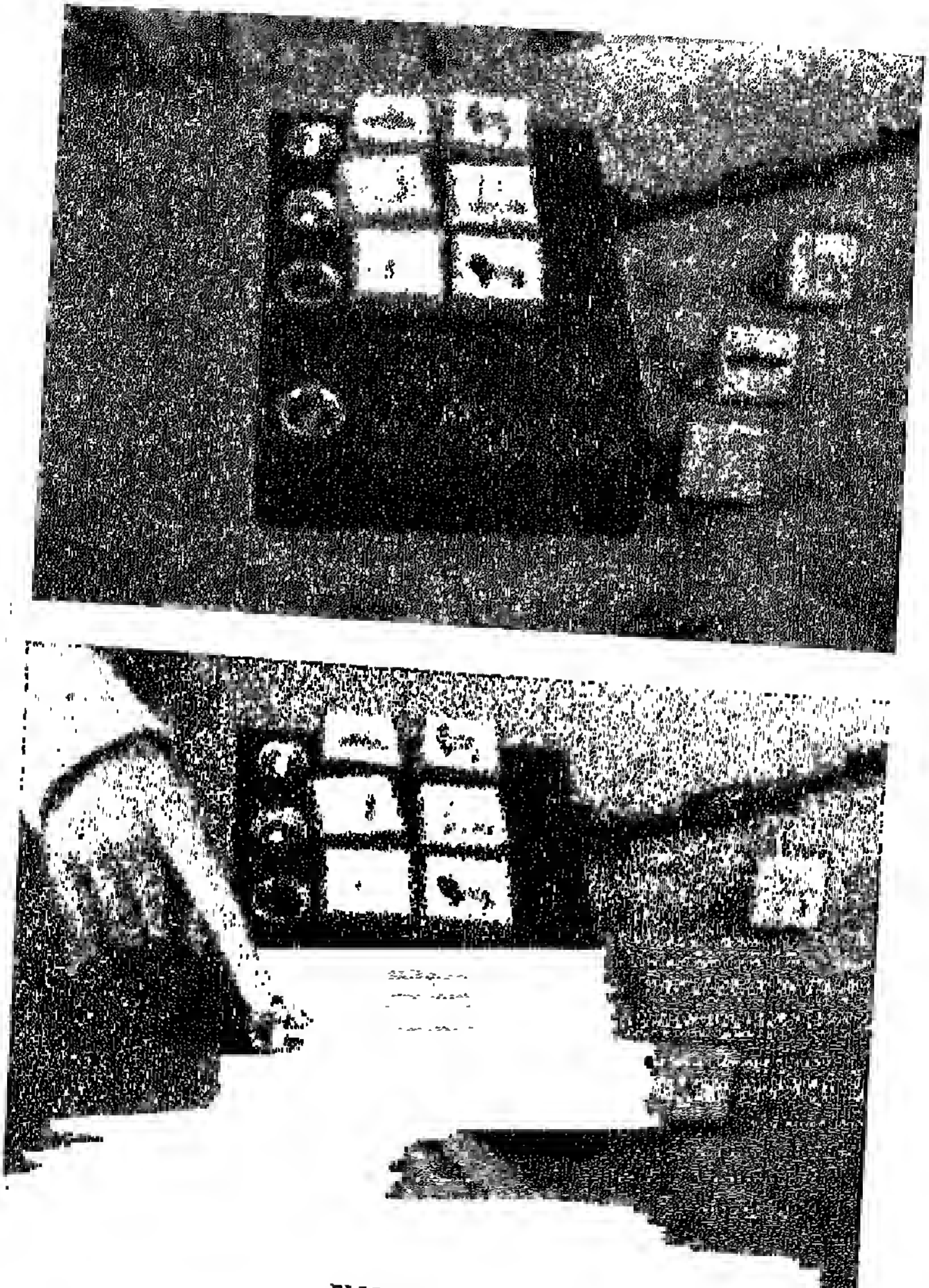
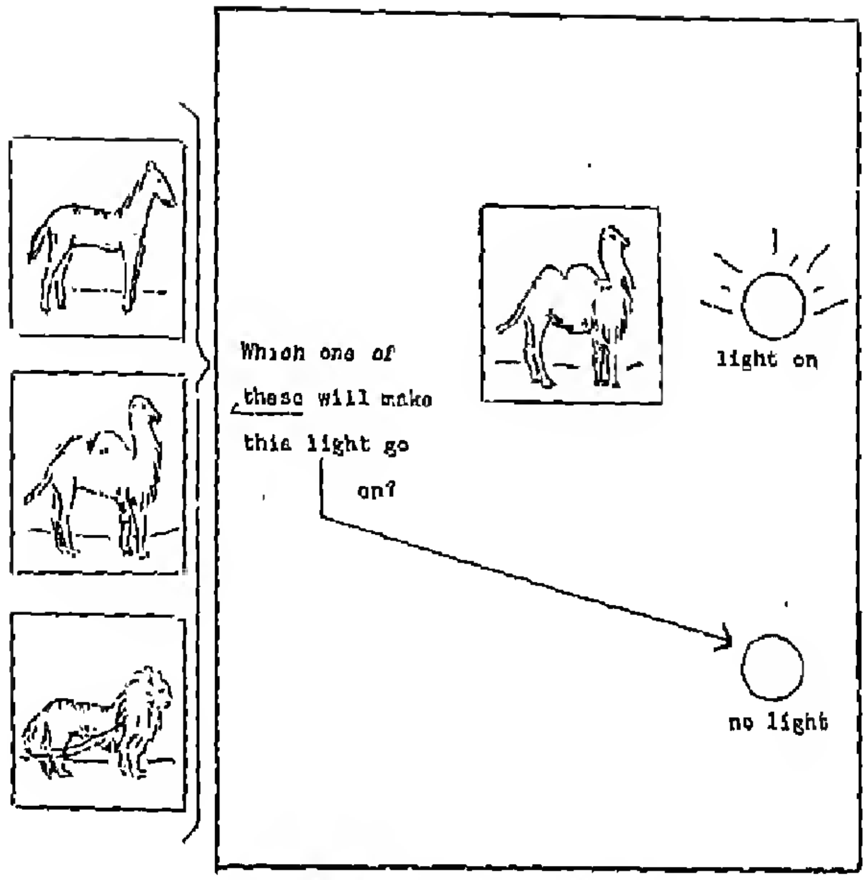


FIGURE 3



(The camel block will make the light go on.)

FIGURE 4
A SAMPLE TRIAL OF PROBLEM 3

tells him what to do without any verbal aid from the experimenter. In Problem 3 he must have a sufficient knowledge of language to understand the quetsion, "What will *make* this light (pointing to the lower one) go on?" or the instructions, "Choose the block that will make this light go on." This word "make" is a symbol of the abstract concept "cause." In more formal language, the instructions would be, "What is the *cause* of the light?", or "What block caused the light to go on?"

The perceptual difficulty in Problem 3 is somewhat different in nature than that in Problem 2. In Problem 2 the child was obliged to establish an adequately strong trace which corresponded to the stimulus compound composed of the visual characteristics of *candy and the box in which he placed the candy*, so that the sight of the box alone would revive the trace of this box and the candy. In Problem 3, the child is obliged to establish an adequately strong trace which corresponds to the stimulus compound composed of the illuminated bulb and the block opposite it. (In Figure 85, it is the camel block and the illuminated bulb.) With the mental set established

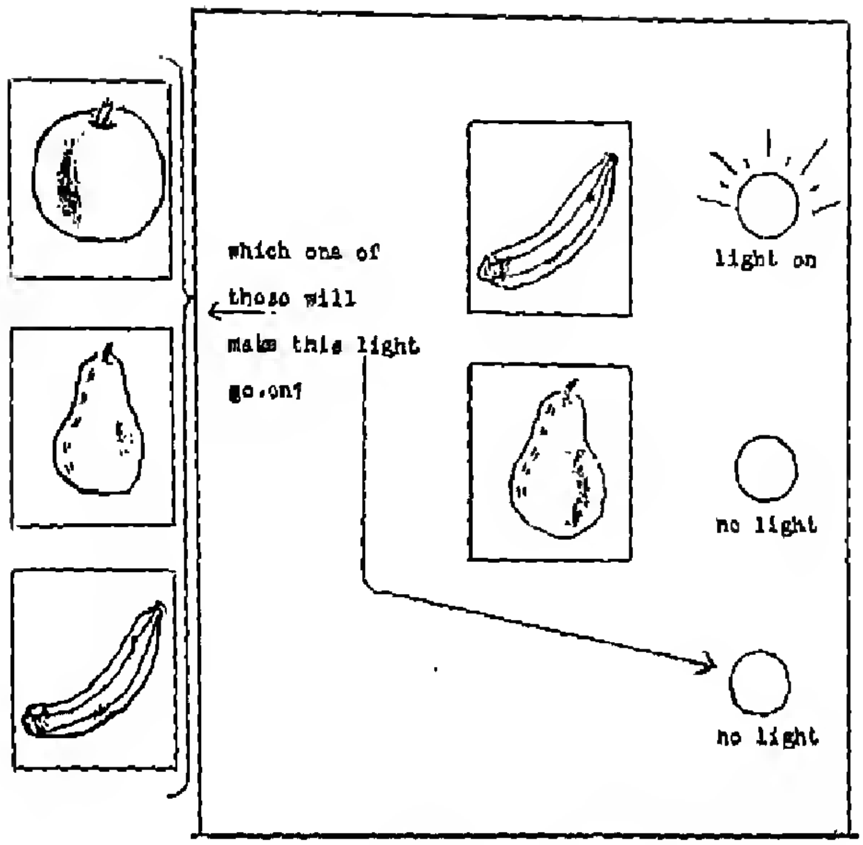
by the instructions, "What will make the bottom light go on?" the camel block at the left of the stimulus compound must emerge from a ground containing the other two blocks. When it emerges it will revive the trace of *camel block and light,* so that the response of choosing the block will be elicited. Now it is not difficult to distinguish the camel from the other animals at the left, nor is it difficult for the subject to remember the camel block and light in the middle of the apparatus, especially when he can keep looking back at it all of the time. *The dominant characteristic that he must perceive and remember is the illumination of the bulb immediately after the camel block is inserted. This can be expressed in terms of the relationship of cause and effect.* This is a characteristic which may be more difficult for the subject to perceive than the slight difference in the size of the boxes in Problem 2. Lastly, in Problem 2, there were only two phenomena that the subject perceived (i.e., two boxes at a time, while in Problem 3 there are four—the light and three different types of blocks.)

Let us summarize the differences between Problems 2 and 3, as follows:

Problem 2	*Problem 3*
No language involved.	Verbal instructions are involved which deal with the abstract concept of "cause."
The relationship essential to the problem is the contiguous relation between candy and the box in which it was placed.	The essential relation is a causal relation between a block and the illumination of the bulb.
There are only two objects involved, i.e., 2 boxes.	There are four different types of objects involved—a bulb and three different types of blocks. Any increase in the amount of data in the visual field increases the difficulty of the essential phenomena to be perceived.

As can be seen in Figure 5, the only difference between Problem 3 and Problem 4 is that there is an additional block and an additional light bulb. There is, however, no causal relation between the block and the light in the second case, for only the highest bulb is illuminated. The instructions and general procedure in both problems are the same.

The additional block and bulb are distracting factors. These factors make it more difficult for the causal relationship between the top block and top light to be perceived. If you turn back and review what we have discussed



(The banana block will make the light go on)

FIGURE 5
A SAMPLE TRIAL OF PROBLEM 4

in connection with the Law of Inclusiveness you will understand more fully why this is so. The additional difficulty of Problem 4 as compared with Problem 3 is not great. Some subjects, however, can solve Problem 3 and fail Problem 4. Adult mental patients in the hospital, who were able to solve Problem 3 and give a satisfactory explanation of why they had made the correct choice, failed Problem 4.

PROBLEMS 5, 6, 7 (INVOLVING FURTHER INCREASES IN PERCEPTUAL DIFFICULTY)

Our next problem (Problem 5) requires the use of Mill's Method of Agreement. In Warren's *Dictionary of Psychology* he defines Mill's Method of Agreement as a "general working principle or canon of induction, which consists in finding many instances of a given phenomenon which all agree in one detail, though differing in other respects, the point of agreement being regarded as the probable cause or effect (or as an indispensible part of cause or effect) of the given phenomenon." If you have had a stomach-ache on

every occasion that you ate doughnuts, among other things, for breakfast, you may conclude that those doughnuts were the cause of your stomach-ache. In this instance you are making use of the Method of Agreement in inductive reasoning. Let us now see how this principle applies to the experimental situation under investigation. In Figure 6, there are

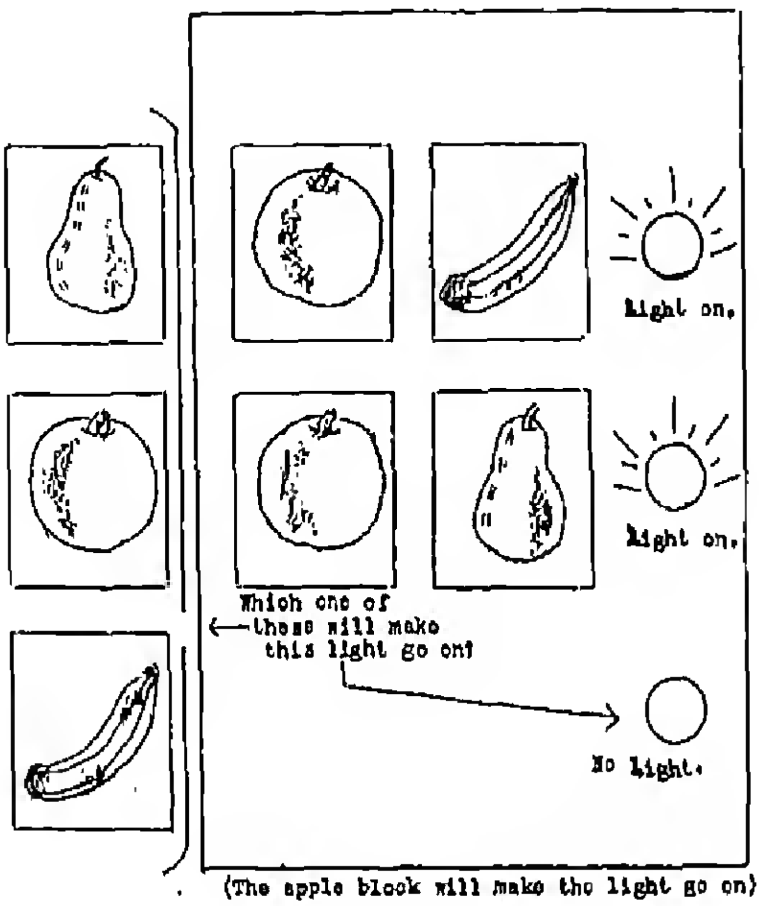


FIGURE 6
A Sample Trial of Problem 5

two rows of two blocks each and *the bulbs in both rows are illuminated.* The block common to both rows (i.e., the apple) is the block which is causing the light to go on. The instructions and general procedure are the same as in Problems 3 and 4. This time the perceptual difficulty has increased greatly. The causal relation appears twice, once in each row. In this problem, however, the essential figure which must emerge from the ground is the causal block which is in close proximity with a non-causal block (see Figure 6).

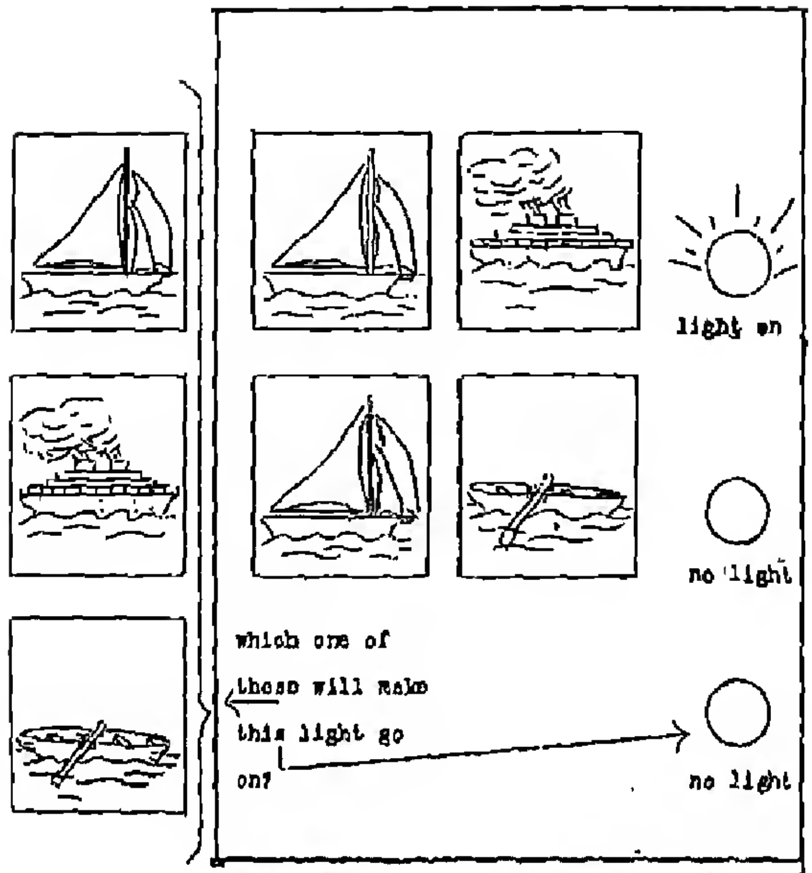
Here, not only similarity, but inclusiveness and proximity are making it more difficult for the subject to perceive the essential causal relationship.

Moreover, the visual field of the subject in this problem includes much more phenomena than in any of the past problem situations.

According to Warren (*ibid.*) ". . . any difference among effects that are otherwise similar is to be attributed to the differences in their antecedents." If you are suffering from a stomach-ache and you recall that you ate this morning, in addition to your usual breakfast of oatmeal and coffee, doughnuts, you may conclude that the addition of this new antecedent (the doughnuts) caused the stomach-ache. In this instance you are making use of the Method of Difference. Let us now see how this principle is applied to the experimental situation under investigation.

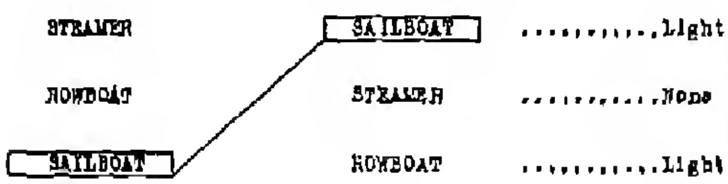
Problem 6 requires the use of this method. In Figure 7 (a sample trial of Problem 6), the steamer block will make the light go on, since it is present in the situation where the light goes on and not in the other. The same number of phenomena are present in both Problem 5 and Problem 6; still, one might suppose that Problem 5 was easier than Problem 6, since in the former, the causal block appears in both rows thus making this block the most conspicuous. For example, in Figure 7 Problem 5 has the apple in both rows. An experiment by Welch and Long (8) demonstrated that there was no reliable difference in the difficulty of these problems for the group as a whole. Some subject, however, solved Problem 6 in two stages: (*a*) They first selected the block common to both rows. When they found that this selection was incorrect, they purposely avoided the "double block" and (*b*) by trial and error discovered which of the remaining two blocks was the correct one. Theoretically speaking, the presence of the causal block in both rows as is found in Problem 5 should make it easier than Problem 6; still, facts indicate that if there is an increase in difficulty it is very slight.

Problem 7 requires the use of Mills' *Joint Method* of agreement and difference. Here, the position of the blocks and lights is as given in Figure 8. The sailboat is the causal block, since it is present in both rows with lights and absent in the row without a light. Perceptual difficulty is increased by the additional phenomena in the visual field, but as facts indicate, the difference is extremely slight. A few mental patients were able to solve Problem 5 and either failed Problems 6 and 7 or had very much more difficulty in discovering the principles for their solution. This difference in difficulty (between Problem 5 and Problems 6 and 7) is not detectable in normal subjects.



(The steamer block will make the light go on.)

FIGURE 7
A Sample Trial of Problem 6

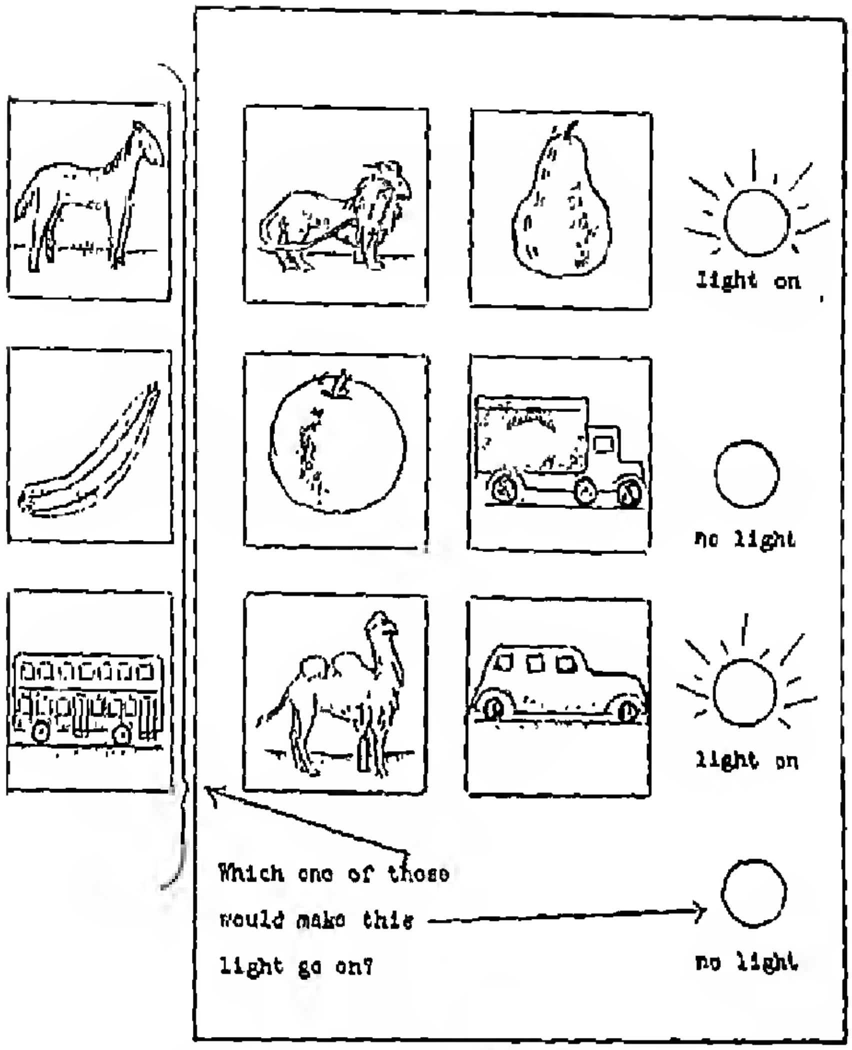


(The names of different types of boats represent the pictures on the blocks.)

FIGURE 8
A Sample Trial of Problem 7

Problems 8 and 9 (Involving an Increase in Abstractness)

Problem 8, like Problem 7, requires the use of Mill's joint method of agreement and difference. Problem 8, however, involves concepts of the 1st hierarchy. In Figure 9, the causal block, common to both rows with lights and absent from the row without a light is a species of animal, *but not the same animal.* The horse block (an "animal" block) at the left is the causal block which will make the bottom light go on. In this illustrated



(The horse block will make the light go on, since here, any animal block is a causal factor).

FIGURE 9
A SAMPLE TRIAL OF PROBLEM 8

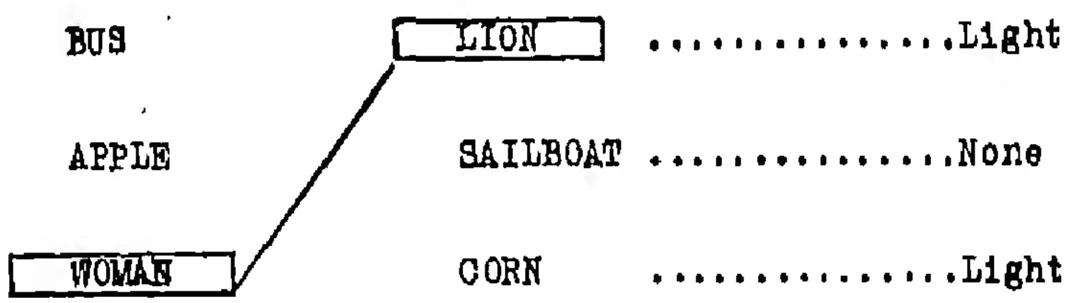
sample trial of Problem 8, three classes are involved, "animals," "fruits," and "land vehicles." The instructions and general procedure in Problems 7 and 8 are the same. The substitution of abstract for concrete material is the only difference between them.

The stimulus compound containing the causal relation under investigation in Problem 7 was "SAILBOAT-AND-ILLUMINATED BULB" in two of the three rows. In Problem 8 the causal relation is between a *class* of objects and the illuminated bulb (e.g., the causal relation between a type of "animal block" and the illuminated bulb). The subject can perceive some similarities between the lion and the camel in Figure 9, but these are not to be compared with the far greater number of similarities between the causal blocks in Problem 7. In Problem 7, the pictures on the causal blocks

are printed from the same negative. *The less similarity between the causal blocks, the more difficult it is to perceive the relation between the causal blocks and the illuminated bulbs.* That is why Problem 8 is more difficult than Problem 7.

In these inductive problems involving two causal blocks, the law of similarity applies to two aspects of the situation. (*a*) *The more similar the causal blocks are to the non-causal blocks, the more difficult it is to perceive the causal relation and (b) the less similar the causal blocks are among themselves, the more difficult it is to perceive the causal relation.*

In Problem 9, 2nd hierarchy concepts are substituted for 1st hierarchy concepts. In all other respects Problem 9 is the same as Problem 8. We shall, however, present the names of the block pictures as they would appear in a sample trial of this problem (Figure 10). Blocks representing the



(The words represent the pictures on the blocks.)

FIGURE 10
A SAMPLE TRIAL OF PROBLEM 9

class of mammals are the causal blocks. The other 2nd hierarchy classes are the class of vehicles and the class of foods. The same principles which explain the increase in difficulty between Problems 7 and 8, make it evident why Problem 9 is more difficult than Problem 8, for here there is still less similarity between the causal blocks (e.g., there is less similarity between a lion and a woman than between a lion and a camel).

Many of the similarities existing between members of a class in these problem situations are not perceivable at the moment. For example, boats are similar in so far as they are "navigable." Their navigability does not appear in the pictures. Hence, the subject must depend upon his memory for some common characteristics which he cannot perceive at the moment.

PROBLEM 10 (INVOLVING AN INCREASE IN MEMORY DIFFICULTY)

We have selected a problem situation constructed by Maier to illustrate a problem (Problem 10) involving increase in memory difficulty (see Figure 11). Two ropes are suspended from the ceiling. The object of the problem is to tie both ends together. When, however the subject grabs hold of the end of one rope and attempts to reach the other he discovers that it is several feet beyond his grasp. You will notice that there is a pair of pliers in this situation. The problem can be solved by tying the pliers on to the end of one rope and then swinging it. If he now

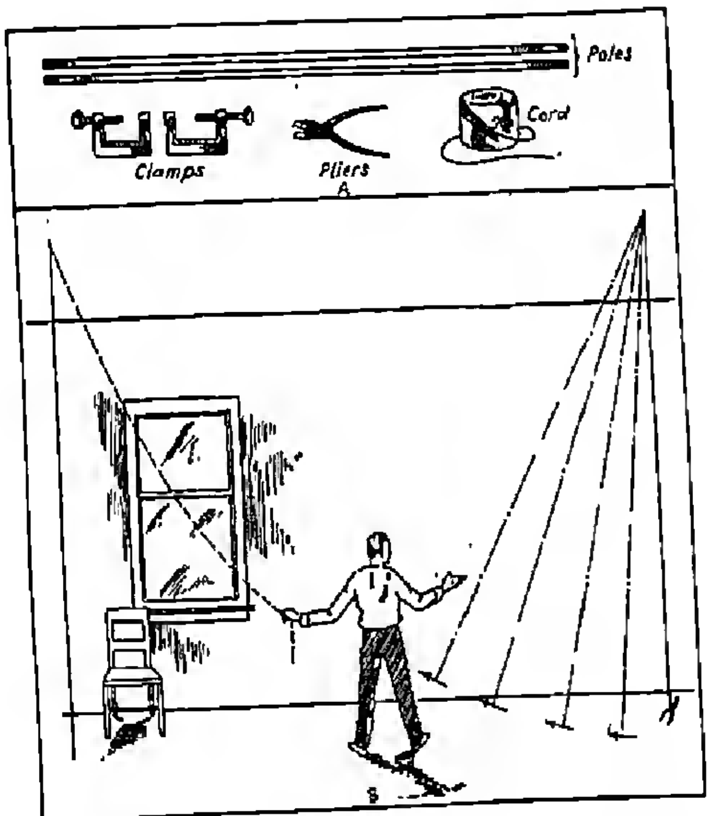


FIGURE 11
MATERIAL USED IN THE MAIER REASONING PROBLEM

grabs hold of the other rope and moves to the center, he will be able to catch the first rope on the up-swing.

The characteristic of ropes essential to the solution of this problem is *the capacity of a rope to swing*. It is hard to believe that any of Maier's college student subjects were totally ignorant of this particular property of a rope. But those subjects who failed, did not, in the time allotted to them, recall this characteristic to mind in relation to reducing the distance between two such subjects. Moreover, during many trials and errors the

ropes may have swung together without the subject *having perceived* the configuration *swing-rope-and-shorter distance between ropes.* This accident of the swinging rope or ropes would have demanded far less of the subject's recall, but . . . the characteristic of well known objects which is essential to a problem situation may fail to be recalled, just as such a characteristic of well known objects which is essential to a problem situation may fail to be perceived.

> Frequency and recency in having perceived swinging ropes, particularly if associated with shortening distance (as when climbing from one rope to another in a gymnasium) might give any of Maier's subjects a particular advantage—one, in fact, which would not indicate any unusual powers of observation or special ability to reason. The revival of his gymnasium scene of perhaps the day before would have only required a narrow generalization involving the application of almost the same act in the gymnasium situation to Maier's situation. Maier has pointed out that the solution of such a problem is achieved only by "direction." According to him "direction" is the integration of individual acts as *tying pliers onto rope, swinging rope, grabbing the other rope, catching the first rope on the upswing* into one whole (5).

In many respects, Maier's "direction" is similar to what we would describe as the process of recombining ideas. In any learning situation, however, recombination of ideas can be only one of the several mental processes that are needed. All are equally important.

In many of the recent problems we have discussed the way the recombination of idea is operating can be partly determined by the hypotheses which the subjects may reveal to the experimenter. The mature subject, in any complicated situation, has some sort of hypothesis or plan. This may come to him suddenly. It may be changed after one or many failures. It is usually a recombination or reorganization of phenomena that the subject perceives at the moment of a phenomena which he recalls.

The Media of Problem Situations

In any learning situation there may be at least three different types of media: three dimensional material, pictorial material, and linguistic material. The number and the vividness of the characteristics of an object are never as great in a picture of that object as in the object itself when we perceive it directly. A description of this object is still more unsatisfactory. The description (2 pages in length) of a piece of apparatus may be difficult for even a trained scientist to understand. A layman, on the other hand

in one or two minutes might obtain a fairly clear idea of the apparatus by direct observation.

We have already spoken of the great value of language. It is indispensible when information cannot be obtained by pictures or by direct observation: still, words "can let us down." Many problems have been failed simply because the subject or student did not understand the instructions or the nature of the material which the problem involved. In those problem situations which involve language, the difficulty of the solution may be explained in terms of (*a*) a lack of clarity in the description of the problem situation (e.g., the description of the apparatus and the way it is used), and (b) ambiguities of language in either the general description of the problem situation or in the directions given.

The block and light problems which we have been discussing become more difficult when the three dimensional material used is replaced by linguistic material. Some mental patients who had no trouble with these block and light problems even when they involved abstract concepts (e.g., the classes of animals, fruits, and boats) were unable to solve the same type of problem when words at the concrete or object level were substituted in place of the three dimensional material. At the linguistic level the subject was told, for example, that a certain individual on one day, ate—

A TROUT and AN EEL and was WELL.
The next day he ate—
A CARP and A TROUT and was SICK.
The next day he ate—
A CARP and AN EEL and was SICK.

He was then asked "What kind of fish would make him sick today—A CARP, AN EEL, OR A TROUT? He was told to cross out the one he thought would make the person sick and to reach his conclusion by using a principle of reasoning and not by any past experiences with food." Here, we have the same problem as No. 7 which we discussed, but on this occasion, the material is linguistic and not three dimensional.

People who invent problems often exploit the ambiguities of language. One example is "What is half of half and half?" The answer is "ale" since the popular name for a mixture of beer and ale is "half and half." The inventor of such a problem hopes that the subject will direct his attention to the realm of arithmetic. We shall find better examples of ambiguities when we discuss certain problems of deductive reasoning.

The instructions given in a problem may purposely mislead the subject

by way of implication. This is obvious in the following: The subject is supposed to draw four lines through all of the dots in Figure 12 without retracing them. At least one end of each line must touch the other. This problem can only be solved by extending two of the lines beyond the square (Figure 13). The inventor of such a problem obviously hoped that the subject would infer that he could *not* extend the lines beyond the square. If he had specifically stated that the subject might extend the lines or had given the instruction "Draw any four lines *part of which* pass through all of the dots, etc." this problem might be too easy. Its difficulty lies in the implication that the lines cannot be extended. Gestalt psychologists would maintain that the difficulty can be explained in terms of the law of pregnanz. The subject's tendency to perceive figures as perfect figures would inhibit him from making an extension of the lines beyond this perfect figure (the square in Figure 12).

The Complexity of a Problem Situation Can be Increased by Two or More Factors

In the problems so far discussed, we have considered the minimum number of factors responsible for an increase in complexity and difficulty. For example, we have seen that a problem becomes more difficult by the mere substitution of abstract for concrete material, by shifting it from the three dimensional to the linguistic realm or by increasing the amount of material in the situation. An increase in complexity may involve several of these factors.

The combination of such factors as they affected learning was studied by Long and Welch (3). Their subjects were first given problems with three dimensional material (i.e., blocks and lights) which required the use of Mills' Joint Method of agreement and difference. If they succeeded in solving these problems, abstract concepts of the 1st and 2nd hierarchies were introduced. They were next given this same type of problem with linguistic material in place of three dimensional material (see Part 1, Table 2). As this series of tests continued the number of antecedents, or *possible* causes of sickness was increased.

In Part 4, the original problem has been made more difficult by (*a*) shifting from three dimensional to linguistic material and (*b*) by increasing the number of antecedents from two to four.

In Part 7, the subjects had to contend not only with the difficulty of

The problem of drawing four lines
through the square of nine dots.

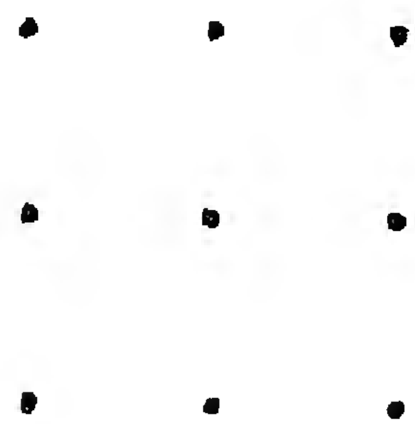


FIGURE 12

The solution to the problem of drawing
four lines through the square of nine dots.

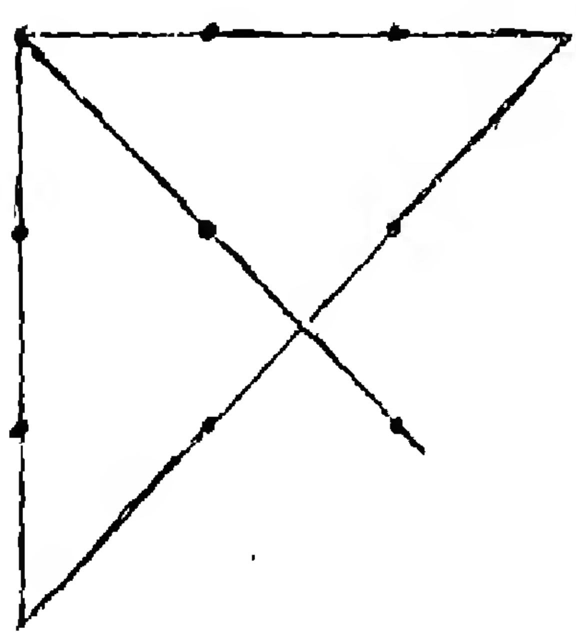


FIGURE 13

language material and an increase in the number of antecedents, *but also with the substitution of abstract concepts.*

In Part 10, the 1st hierarchy concepts of Part 7 are replaced by 2nd hierarchy concepts. These proved to be the most difficult problems of the series.

We must not forget, however, that some types of abstract concepts are more difficult than others. For many people numerical concepts are more difficult than object class concepts of a high level of abstractness.

TABLE 2
INDUCTIVE PROBLEMS OF INCREASING COMPLEXITY
(These involve an increase in the number of antecedents and increase in abstractness.)

Part 1

TROUT	EEL	WELL
CARP	TROUT	SICK
CARP	EEL	SICK

carp, Eel, Trout

Part 2

CLAM	CRAB	WELL
CRAB	OYSTER	SICK
OYSTER	CLAM	SICK

Clam, *oyster*, Crab

Part 3

COCA COLA	COCOA	TEA	SICK
GRAPEFRUIT	GINGERALE	COCA COLA	SICK
GRAPEFRUIT	GINGERALE	MILK	WELL
MILK	TEA	COCOA	WELL

Gingerale, Cocoa, *coca cola*, Milk, Grapejuice, Tea

Part 4

SQUAB	GROUSE	PHEASANT	CHICKEN	WELL
PARTRIDGE	QUAIL	GROUSE	PHEASANT	SICK
QUAIL	GOOSE	SQUAB	DUCK	WELL
DUCK	PARTRIDGE	CHICKEN	GOOSE	SICK

Pheasant, Quail, *partridge*, Goose, Squab, Duck, Grouse, Chicken

Part 5

PERCH	PEAR	SICK
TABASCO	PEACH	WELL
KETCHUP	FLOUNDER	SICK

Gravy, Plum, *carp*

Part 6

GOOSE	CLOVES	MILK	SICK
COCA COLA	CORN	GROUSE	WELL
POTATO	CLAM	GUM DROP	WELL
BONBON	CINNAMON	LOBSTER	SICK

Chicken, Fudge, *nutmeg*, Crab, Gingerale, Beet

TABLE 2 (*Continued*)

Part 7

HAM	PEAR	OATMEAL	SHREDDED WHEAT .... SICK
BEEF	LIFE SAVERS	BEER	PUFFED RICE .... WELL
PEACH	NUTMEG	PEANUT BRITTLE	OYSTER .... SICK
CRAB	SHERRY	PORRIDGE	CINNAMON .... WELL

Lollipop, Cloves, Clam, Claret, Venison, *apple,* Mush, Cornflakes

Part 8

LIFE SAVERS	BEEF .... SICK
BASS	QUAIL .... WELL
BONBON	CRAB .... SICK

fudge, Ham, Oyster

Part 9

SHREDDED WHEAT	BEEF	CORN .... SICK
CHICKEN	PLUM	NUTMEG .... SICK
STRING BEANS	MUSH	FLOUNDER .... WELL
OYSTER	TABASCO	GRAPEFRUIT .... WELL

quail, Ketchup, Potato, Cream of Wheat, Clam, Peach.

Part 10

GROUSE	LOLLIPOP	CORNFLAKES	KETCHUP .... WELL
CLAM	COFFEE	PEAR	SHERRY .... SICK
SHAD	OATMEAL	LEMON	SPINACH .... SICK
FUDGE	CLOVES	SQUASH	LAMB .... WELL

Ham, *puffed rice,* Lobster, Peach, Tabasco, Gingerale, Beet, Peanut brittle.

Children of 13 years of age who had little difficulty in solving the type of problem we have illustrated in Part 10 of Table 2 had great difficulty with the following type of problem which is similar to Problem 5. This only requires the use of Mills' Method of Agreement, *but number concepts are substituted in place of the pictures of animals.*

> You have a—
> 34 and an 11 and you get a "+"
> You have a
> 13 and 85 and you get a "+"
> What class of number is causing the "+"?

This time we are not dealing with the class of "animals," "fruits," or "boats," but that more unique class— the class of numbers that is *divisible by 17.* Observe—34 and 85 are divisible by 17. Divisibility by 17 is common to both numbers, therefore we can speak of them as belonging to the same class. The common characteristics of the numbers of the classes, animals, fruits, and boats are much more obvious to the average person than this comparatively unusual characteristic of the numbers 34 and 85. It is your unfamiliarity with the haunts and habits of 34's and 85's that makes

this problem difficult. The form of the problem itself is not difficult. Certainly, you had no trouble in solving Problem 5 with pictures. Many children nine years of age solved Problem 5 almost immediately, but many college juniors and seniors only solved five out of 10 of this type of numerical problem.

So far our transition from simple learning situations to those of increasing complexity has ranged from type of problem that children two years of age have solved to those which brilliant college students in their third and fourth years have failed.

Problems of Deduction

All of the learning situations that we have so far studied required induction. According to the logician, induction involves arriving at a generalization from particular instances, whereas, deduction involves arriving at a particular conclusion from a generalization. The distinction between these two processes is not very important in the field of psychology. . . . Solutions may be reached just as easily by means of induction as by deduction and the distinction is quite inconsequential in explaining the mental processes that operate. For example, a subject might observe that on 10 different occasions he ate fish and became ill. He might then conclude that if he eats fish on *this* occasion he will again become ill. On the other hand, for similar reasons he might believe that any or all fish will invariably make him ill, and after identifying a dish placed before him as an order of fish, conclude that this will make him ill. The first is an example of deduction. The second is an example of deduction. We have a tendency from birth to make wide generalizations which are often faulty. One great value of studying logic is in learning the dangers of most generalizations. If for example a person were to arrive in a foreign country and be treated rudely by the first 10 inhabitants he meets during the first two days, he might conclude that all of the inhabitants were unpleasant people. If he reaches this faulty conclusion, which is the result of induction, he may use the generalization in making a deduction. For example, if he were to conclude erroneously that this particular inhabitant is unpleasant because of his prior belief that all of the inhabitants are unpleasant, he is making a deduction—he is arriving at a particular conclusion from a generalization. Even if a generalization is true we may draw the wrong conclusion from it. The rules for drawing a correct inference from a generalization are found in logic.

The most elementary form of deductive inference is the simple syllogism which is composed of three statements or propositions—*the major premise,* which is the generalization (e.g., all men are mortal), *the minor premise* a particular statement or proposition (e.g., Socrates is a man) and the conclusion (e.g., Socrates is mortal).

Deductive inferences as they appear in our daily speech are not of the orderly type:

> All men are mortal
> Socrates is a man
> Therefore, Socrates is mortal.

Usually, the essential propositions are mixed with other expressions of thought. The logical order of the major and minor premises and conclusion may be reversed or one of the premises may be merely implied. For example:

> There is very little in this life that is of great merit. We acquire wealth and we lose it. Our lives are temporary. This is true of the wise and the great, as well as of the foolish and the lowly. Even the great Socrates in the days when he questioned his friends in the market-place, was despite all of his wisdom, looked upon by everyone as a mortal creature. "Socrates is mortal," anyone in Athens could well have said. No doubt they did, for alas, even then as now, the simplest mind knew that all men are mortal.

In order to check the deductive inference that Socrates is mortal in the above paragraph, one must first discover the major premise and then the implied minor premise (i.e., "Socrates is a man"). When the premises and conclusion are written down in their logical order, it is easier to detect a fallacy, if one is present. Even when a deductive inference is presented in the compact form of a syllogism, a fallacy may be hard to detect, particularly if the conclusion is true. A conclusion may be a matter of fact, but if it does not follow from the premises, the deduction is fallacious. For example, the proposition "All good men are not liars" is true, but it does not follow from the premises:

> No liar can be believed
> All good men hate liars
> Therefore, all good men are not liars.

The problem of discovering a fallacy in a deductive argument consists in discovering whether logical relationships exist between the premises and the conclusion. The symbols of relationships between these parts, whether

logical or illogical, must emerge from the visual field of the problem solver in much the same way that the causal relationships emerged in many of the inductive problems already discussed (where the cause was a block or some type of food and the effect was the illumination of a bulb or sickness).

In many of the more difficult deductive problems the complexities and ambiguities of language are found. The more obvious type of ambiguity is apparent in the subject or predicate of the conclusion and of the premises as in the following:

> *Nothing* is better than heaven,
> (Subject)
> A dollar is better than nothing.
> Therefore, a dollar is *better than heaven.*
> (Predicate)

The meaning of such ambiguous terms as "all" or "some" may cause even greater difficulty. A reason for this is given by Woodworth and Sells (12). "Ambiguity" they state "attaches especially to the word 'some' as in 'Some X is Y.' By the conventions of formal logic, 'some' means 'at least some' (i.e. 'some and perhaps all') while in ordinary speech it often carries the implication of some but not all." They also suggest that the use of a preposition which is of the form "SOME *S* is *Y*" appears more cautious to the layman than the use of one which is in the form "ALL *X* is Y." A syllogism with the conclusion "SOME *X* is *Y*" can be just as fallacious, however, as one with the conclusion "ALL *X* is Y."

In an experimental study made by Wilkins (10), it was found that the difficulty of detecting fallacies in syllogisms depended in part upon the familiarity of the problem solver with the materials involved. Students taking these tests made the fewest mistakes in detecting fallacies in syllogisms which dealt with everyday college life (e.g., all undergraduates must learn to swim. This Junior is an undergraduate. Hence, he must learn to swim). They made more mistakes with syllogisms of the same type which involved the use of letters (e.g., all *X* is *Y*, etc.). Their worst scores were made in detecting fallacies in syllogisms making use of nonsense-syllables (e.g., all *Xips* are *Mefs*, etc.). Certainly, the meaningfulness of the subject matter aids the problem solver in applying the rules of logic that he has learned.

Rules of logic not only acquaint us with the various types of ambiguities which may appear in deductive arguments, but aid us in arranging or re-arranging the premises and conclusion in an order that brings the logical

relations involved into prominence. This knowledge may soon be forgotten, if the habit of applying the rules of logical frequently is not developed. In an unpublished study made by Welch and Long, the same syllogistic problems were given to three different groups of college juniors and seniors. None of the members of the first group had ever taken a course in logic. All of the members in the second group had passed their examinations in a one-term course in logic four months prior to the test, and all of the members of the third group were ending a one term course in logic. The average scores of the first two groups were almost identical. The average score of the third group was reliably higher than those of the others. Thus it can be seen that the ability to apply the rules of logic learned in one college term, if not deliberately applied, may disappear in the very short span of three or four months.

The Simultaneous and Consecutive Functioning of the Mental Processes in Learning Situations

Even in a simple conditioning situation the mental processes of perceiving and recalling functioned simultaneously. When the dog was conditioned to salivate to the sound of a bell of low pitch, he would even salivate on hearing one of a higher pitch. In this second instance, we have an example of the simultaneous functioning of three mental processes—perceiving, recalling and generalizing.

When we attempt to study the mental processes which are functioning at any given moment in a complex problem situation our task becomes impossible. All we can say is that there is both simultaneous functioning of some or all of the mental processes and consecutive functioning of them as well. Difficult problems often have to be solved in stages. In very difficult problems of higher mathematics for example some people may be able to pass through various stages more quickly than others; still, if the problem is sufficiently difficult everyone must pass through all of the stages involved.

Frequently passing from one step to another may be extremely slow. A great deal of time may be spent and many errors made in one step alone. At another point, the problem solver may pass quickly through one or several steps; still, in all of these problems that must be solved one step at a time, there is the additional difficulty of efficiently directing the mental processes so that the relationship between one step and another is dealt with adequately. It might be convenient to think of a difficult problem in calculus as a chain of logically related problems only one of which is solvable at

a time. In so far as these problems are logically related, however, perception, memory, and generalization must be taxed to the extent that most of the essential elements which belong to each problem are included. Thus, as the complexity of the problems stretches out through many stages, the integrated activities of the mental processes are proportionally taxed.

The simultaneous and consecutive functioning of mental processes particularly in the more complex learning situations, includes the recombination of ideas and association. In the fantasy of both the dream and the waking states, parts and characteristics of different phenomena that we have perceived are recombined. For example, we have seen mountains and gold watches, but never an actual gold mountain. We can, however, recombine characteristics of both impressions and have an image of a gold mountain. Similarly, in a learning situation which might be referred to as reasoning or a problem solving situation, recombination of ideas plays an important part. This is not only true of impressions that we have perceived, but elements of the past impressions may be recombined with what we are perceiving at the moment.

To some extent the capacity to recombine ideas is dependent on the associative activity of the individual. Just as we cannot recombine elements of impressions that were never made, so too, we cannot recombine elements of impressions we cannot recall or revive by the process of association. The rate of associative activity admits of difference. In a study by Welch, Long, and Diethelm (9) it was shown that a stimulant such as dexaedrine could increase the flow of associations to a list of nonsense-syllables of low association value.

Summary

We have analyzed a series of problems to show the various factors involved in the transition from simple to complex forms of learning. We have included (*a*) the factors which pertain to the stimulus configuration itself; (*b*) the number and the efficiency of the following mental processes, perception, memory, recall, generalization, association and the recombination of ideas; (*c*) the time element; and (*d*) the conditions of learning.

(*a*) We have seen that the laws governing the emergence of a figure from a ground must be considered in the examination of those factors which tend to increase the difficulty of these learning situations. (*b*) An increase in the difficulty of a learning situation has also been explained in terms of the substitution of abstract material for concrete material and substitu-

tion of written for three dimensional material. (*c*) We have also seen that as we pass from the simple to the complex learning situation, we must use a greater number of mental processes simultaneously and consecutively and with greater efficiency in each instance. (*d*) The time element plays an important part in the analysis of all learning situations. In simple animal experimentation learning is usually studied in terms of the rate at which the animal eliminates his mistakes. In any problem box or maze the animal may reach his reward on the first "run." He is however, put back into this same situation many more times so that the experimenter may study how *long* it takes him to discover *short cuts* to his food. Again, many an animal or human subject has failed to solve a problem in the time allowed; yet, had such a subject been granted one minute, ten minutes, or an hour longer, the solution of the problem might have been reached. The additional time would not only have involved longer activity of the subject's mental processes, but also the conditions of learning.

(*e*)The conditions of learning to which we refer include what would ordinarily be called conditioning, trial and error, insight, and even practice and imitation (in the problems we have just studied little or no opportunity for imitation was found). It is absurd to attempt to describe learning in terms of one of these conditions alone. Certainly, in any simple learning situation, not only are the principles of conditioning applicable, but *all* that we mean by trial and error is also present. When we turn to complex learning situations, there is no reason to suppose that the factors of conditioning are absent. The non-conditioned stimuli, the conditioned stimuli (particularly when generalization is involved) and the responses may not be as obvious as in the situation of Pavlov's dog. Moreover, the trials and errors may be more numerous and the opportunity for observing the subject's "insight" or hypothesis making may be greater.

In insight or hypothesis making the subject "perceives" or believes he perceives the relationship between the means and the goal. This so-called perception is not solely the direct result of a stimulus configuration impinging upon one or several of the subject's sense receptors. The relationship between mean and goal may involve the relationship between phenomena that is actually being perceived by the eye, ear, etc., and revived impressions of the past or the recombination of all these phenomena. Again, the hypothesis may only carry the subject from the first to the second stage of the solution of the problem. In other words, the relationship between the means and the goal must not be thought of, in all instances, as involving

the ultimate goal, since many problems, as we have suggested, are only solvable in stages.

This study could be described as the examination of a transition from simple reasoning problems to complex reasoning problems, though some of the problems considered would ordinarily be described as tests of visual discrimination. If the term *reasoning* were used, it should represent the simultaneous or consecutive integrated activities of several or all of the mental processes we have described. It is confusing to use the term reasoning as a mental process in the same sense that we speak of perception or memory as mental processes. When we think of reasoning as the integrated activity of perception, memory, recall, association, generalization, and recombination of ideas we may hope to find the specific cause of failure in any so-called reasoning situation. So often failure is the result of poor perception or memory, or what we have not mentioned, attention or motivation. If on the other hand we treat reasoning as a mental process itself, all we can hope to achieve in analyzing failure in the reasoning situation is to state that the failure was due to poor reasoning.

Throughout this study we have described a transition from simple to complex learning situations and have avoided the distinction between reasoning and problem solving, since this so often implies that if one reasons, he does not "problem solve," or if he solves problems, he does not reason.

References

1. Crafts, L. W., Schneirla, T. C., Robinson, E. E., & Gilbert, R. W. Recent experiments in psychology. New York: McGraw-Hill, 1938. (See Chapter XXV.)
2. Long, L., & Welch, L. Reasoning ability in young children. *J. of Psychol.*, 1941, **12**, 21-44.
3. ———. Factors affecting efficiency of inductive reasoning. *J. Exper. Educ.*, 1942, **10**, 252-264.
4. ———. Influence of levels of abstractness on reasoning ability. *J. of Psychol.*, 1942, **13**, 41-2.
5. Maier, N. R. F. Reasoning in human. *J. Comp. Psychol.*, 1930, **110**, 115-143.
6. Welch, L. The development of size discrimination between the ages of 12 and 40 months. *J. Genet. Psychol.*, 1939, **55**, 243-268.
7. ———. Some aspects of the development of inductive reasoning. *Trans. New York Acad. Sci.*, 1940, **4**, 218-221.
8. Welch, L., & Long, L. Methods used by children in solving inductive reasoning problems. *J. of Psychol.*, 1941, **14**, 269-275.
9. Welch, L., Long, L., & Diethelm, O. Measurement of hyper-associative activity during elation. *J. of Psychol.*, 1944, **21**, 113-126.

10. WILKINS, M. C. The effect of changed material on the ability to do formal reasoning. *Arch. of Psychol.*, 1928, No. 160.

11. WOODWORTH, R. S. Experimental Psychology. New York: Holt, 1939.

12. WOODWORTH, R. S., & SELLS, S. B. An atmosphere effect in formal syllogistic reasoning. *J. Exper. Psychol.*, 1935, **19**, 451-460.

Institute for Research in Clinical and Child Psychology
Hunter College
695 Park Avenue
New York City

SHORT ARTICLES AND NOTES

The Journal of Genetic Psychology, 1947, 71, 253-257.

THE USE OF AN AUTOBIOGRAPHY IN A COURSE IN ABNORMAL PSYCHOLOGY*

Department of Psychology, New York University

DANIEL BROWER

For the past three semesters the author has required each member of his undergraduate ABNORMAL PSYCHOLOGY classes to write a brief autobiography as an integral part of the course. Having found many interesting results, a tentative report is presented here in the hope that others will be provoked to express their opinions and experiences in the use of this method.

Any college course can be taught on several levels: It may merely aim at providing information, it may aim to provoke one's thoughts, or it may aim to improve the individual's state of personal and social adjustment. The author's educational philosophy is such that his course in ABNORMAL PSYCHOLOGY aims at all three educative levels mentioned above, but tends to stress the personalization of the material covered in the course in the hope that more insight may be gained by at least a large proportion of the students. Ideally, of course, the personalization of the subject matter, or the concretization upon the self, would best be accomplished by extensive depth interviewing. In large classes, however, this is not feasible. So the alternative of requiring the autobiography as a term assignment was adopted and those students who felt, as a result of writing the paper, that they wanted to talk to the instructor were encouraged to engage with him in short interviews, on the basis of which a small number were referred for psychiatric consultation.

The author hopes, also, to imbue students with the conviction that mental deviations are *universal* in all of us to varying *degrees* in various situations and times, rather than the traditional dichotomous view of abnormal *people* being sharply distinguishable from normal *people*.

The technique of autobiographic writing, therefore, may serve to measure, in a crude way, the extent to which the point of view of the course—the

*Received in the Editorial Office on October 28, 1946.

personalization of the subject matter—does take hold. It may also show whether this method has any value as mental hygiene and whether any disadvantages tend to accrue therefrom.

The purpose of the assignment, from the student's point of view, was to determine the degree of success with which he could apply psychodynamic concepts derived from the course to his own life experiences and adjustments. It was stressed that sponttaneity was paramount even at the expense of grammatical error. The students were asked to avoid excessive splitting up of detail and to write the paper in a few long sessions. They were assured of the confidential character of the data. To guide them in structuring the papers, they were referred to the *Outline for Writing a Case History* in Young's book (1). This report is based on the experience with over 300 undergraduate students.

The response to the assignment was one of initial anxiety coupled, in some instances, with resentment followed later by cathartic relief and even gratitude for being forced into such self-discovery. Only one student out of 300 actually refused, in effect, to do the task. All the others were about equally divided between those who managed to work the task out by themselves and those who asked for varying degrees of aid. In the latter instances a very non-directive type of guidance was employed.

Many students reported better social adjustment after doing this chore. One girl broke her engagement in the middle of the paper and felt much happier for it. She had described what amounted to her oedipal difficulties in the paper. Many showed anxiety regarding job and career. A large number of the men, especially the veterans, came to realize the need for vocational guidance and clinical psychological aid and were alternately disappointed and hostile for the limitations in such facilities generally available. One boy used the medium of this paper to let his girl find out about his diabetic condition by reading to her his introspections about the rôle of this disease in his life, whereas he could not bring himself to tell her verbally. Many students expressed the thought that they would be able to know in the future when a psychiatrist's services are needed before it is too late, and will probably not be too intensely victimized by the stigmatization of visiting a psychiatrist. In fact, a large number of the groups felt that they would like to enter the fields of clinical psychology or psychiatry.

A large number reported early sexual experience such as playing "Doctor and Nurse" and other forms of mutual undressing, inspection, and stimulation, masturbatory experiences, as well as heterosexual experiences, strivings,

frustration, and anxieties. Males were, naturally, less inhibited in the sexual sphere, partly because of differential mores and partly because of the fact that the reader was male. Two cases of serious sexual deviation came to the author's attention through the medium of this paper and the interviews resulting therefrom and were referred for psychoanalytic therapy.

The best papers were certainly those which were most spontaneous and which were executed by those students who took the course and this paper, in particular, not merely for the three points of credit but to find out more about themselves. Such students who already have some peripheral insights when starting the course can profit the most from a student-centered abnormal psychology, in which the student is encouraged, even urged (through this paper), to study himself rather than the other fellow; to turn the sights of his perceptual guns inward upon himself.

Some students personalize the beginnings of their writings by notations of apology, pleas for strict confidence, confessions that the initial draft was censored, etc. The endings are usually in the form of summarizing the structure of the personality, an optimistic note or two about the future, and occasionally, a metaphysical note.

One female student of Japanese extraction discovered the origins in her folk-lore and childhood experiences for her visual hallucinations which ceased before the end of the course. Three students admitted having homosexual experiences, one of whom found that his system of rationalization broke down upon writing the paper. At various crucial dynamic points in the essay a student would divert into verbal protest over the assignment. Many have reported that their inferiority feelings had disappeared, feelings of self-esteem had risen, and that it is annoying, at first, to find out about your abnormalities but that it is later gratifying to learn that we are all somewhat that way, i.e., neurotic or maladjusted.

After turning in their papers each student was asked to anonymously answer several questions regarding this autobiographic experience. The questions with the summary of results follow:

1. What was the greatest value which you received from this course, if any?

   Greater insight into self and others, and greater tolerance for others.

2. How has this course affected your state of happiness?

   About 75 per cent said happier; 20 per cent no change; and 5 per cent less happy; "shook me up," "agitated," etc.

3. Since this course started are you aware of dreaming more or less often, or is there no change?

About 60 per cent no change; 20 per cent more often; 20 per cent less often.

4. Since this course started have your inter-personal relations shown any change?

About 70 per cent said more satisfying; 25 per cent reported no change; and 5 per cent find their social adjustments less satisfying.

5. Do you feel differently about yourself as a result of this course? If so, how?

About 70 per cent reported greater assurance and security and heightened self-esteem; 30 per cent little or no change.

6. State the effect of the autobiography assignment upon you.

Practically every student expressed the idea of greater insight and knowing of one's self.

7. Would you rather have been assigned a library type of term paper instead of the autobiography?

Only 7 per cent said yes. Many of the others did, of course, indicate that while doing the paper they had hoped that the assignment had never been made but that this feeling changed after turning in the paper.

Many students asked why the course was not supplemented by a psychological clinic. A large number said that a course never took so much time and energy but that they felt it was well worth it.

From the instructional and evaluative points of view, it was clear in each section that, with regard to the amount of insight displayed and the success in applying the principles of the course to the self, the papers tended towards a bimodal distribution of very low and very high degrees of insight.

From the results reported above it would seem reasonable to hazard a guess that about 5 per cent of the undergraduate students in a course in ABNORMAL PSYCHOLOGY experience or suffer an increase in their states of tension, maladjustment, or unhappiness or combinations of these reactions. Many of these were probably maladjusted to begin with and the course and paper served merely to focalize attention upon their difficulties or, having made some unconscious material conscious, the therapeutic function of the course stopped at the point where the individual was just about to attain the proper mental set for intensive therapy. As far as the clinical insight of the author permitted, these people were referred for therapy outside of the classroom and University situation. Each was asked, however,

to report back to the author for a check-up on the subjective effects of their therapy. It would seem that if such precautions are consistently taken there is little danger in teaching such a course from a dynamic and personalized point of departure; in fact, the effects are in the positive direction if one is able to help a few disturbed people find out about themselves and again the few morsels of insight which they require to be adequately motivated to seek and pay for psychotherapy. For the vast majority of the students, about 95 per cent, the results are apparently both subjectively and objectively advantageous in terms of understanding the self and others.

The following final sentence of one student's paper might serve to illustrate the degree of penetration which some students derived in the course of this assignment:

> In conclusion, I wish to state that I feel the value of this autobiography to the writer lies in the insight gained into those difficulties, feelings, tensions, and problems which he *does not* write down in this paper.

It should also be stressed that possible disadvantages have emerged in the use of this method. Firstly, in addition to those who take this course for professional preparation, a disproportionate number of students experience an abrupt diversion from other career goals toward clinical psychology and psychiatry. Secondly, some tend toward over-introspectiveness and believe that mere verbalization of a problem constitutes the solution of that problem. This is reminiscent of the terminological or verbal fallacy in science generally. Lastly, some students might feel that, through this autobiography, they have gained complete insight into and control over a problem where the insight gained is partial or the problem was merely verbalized.

Reference

1. Young, K. Personality and Problems of Adjustment. New York: Crofts, 1944.

Department of Psychology
Washington Square College of Arts and Science
New York University
New York 3, New York

The Journal of Genetic Psychology, 1947, 71, 259-268.

BOOKS

The *Journal of Genetic Psychology*, the *Journal of General Psychology*, and the *Journal of Social Psychology*, will buy competent reviews at not less than $2 per printed page and not more than $3 per printed page, but not more than $15.00 for a single review.

Conditions. Only those books that are listed below in this section are eligible for such reviews. In general, any book so listed contains one or more of the following traits: (*a*) Makes an important theoretical contribution; (*b*) consists largely of original experimental research; (*c*) has a creative or revolutionary influence in some special field or the entire field of psychology; (*d*) presents important techniques.

The books are listed approximately in order of receipt, and cover a period of not more than three years. A reviewer must possess the Ph.D. degree or its equal in training and experience.

Procedure. If among the books listed below there is one that seems important to you, you are invited to write a review of that book. It is not necessary to make arrangements with the Editor. Just send in your review. It does not matter if the book in question has been reviewed before.

(1945)

MURPHY, G., *Ed.* Human Nature and Enduring Peace. New York: Houghton Mifflin, 1945. Pp. 475.

FREUD, A., *et al.* (*Editors*). The Psychoanalytic Study of the Child. (An annual, Vol. 1.) New York: International, 1945. Pp. 423.

FLÜGEL, J. C. Man, Morals, and Society. New York: International, 1945. Pp. 328.

RAPAPORT, D. Diagnostic Psychological Testing. (2 vols.) Chicago: Yearbook, 1945. Pp. 573 & 516.

WERTHEIMER, M. Productive Thinking. New York: Harper, 1945. Pp. 224.

LEWIS, N. D. C., & PACELLA, B. L. Modern Trends in Child Psychiatry. New York: International, 1945. Pp. 341.

(1946)

HARRIMAN, P. L., *Ed.* Twentieth Century Psychology. New York: Philosophical Library, 1946. Pp. 712.

MASSERMAN, J. H. Principles of Dynamic Psychiatry. Philadelphia: Saunders, 1946. Pp. 322.

SEWARD, G. H. Sex and the Social Order. New York: McGraw-Hill, 1946. Pp. 301.

SMITH, B. L., LASSWELL, H. D., & CASEY, R. D. Propaganda, Communication, and Public Opinion. Princeton: Princeton Univ. Press, 1946. Pp. 435.

MORENO, J. L. Psychodrama. New York: Beacon House, 1946. Pp. 429.

SYMONDS, P. M. The Dynamics of Human Adjustment. New York: Appleton, Century, 1946. Pp. 666.

HARRIMAN, P. L. Encyclopedia of Psychology. New York: Philosophical Library, 1946. Pp. 897.

GESELL, A., & ILG, F. L. The Child from Five to Ten. New York: Harper, 1946. Pp. 475.

GESELL, A. The Embryology of *Behavior*. New York: Harper, 1946. Pp. 289.

DUNLAP, K. Personal Adjustment. New York: McGraw-Hill, 1946. Pp. 446.

DUNLAP, K. Religion: Its Functions in Human Life. New York: McGraw-Hill, 1946. Pp. 362.

RICHARDS, T. W. Modern Clinical Psychology. New York: McGraw-Hill, 1946. Pp. 331.

WOLFF, W. The *Personality* of the *Preschool* Child. New York: Grune & Stratton, 1946. Pp. 341.

FREUD, A. The Ego and the Mechanisms of Defense. New York: Internat. Univ. Press, 1946. Pp. 196.

BLAU, A. The Master Hand. New York: Amer. Orthopsychiat. Assoc., 1946. Pp. 206.

CATTELL, R. B. Description and Measurement of Personality. Yonkers: World Book, 1946. Pp. 602.

(1947)

SHERIF, M., & CANTRIL, H. The Psychology of Ego-Involvements. New York: Wiley, 1947. Pp. 525.

FLUGEL, J. C. Men and Their Motives. New York: International, 1947. Pp. 289.

ALLPORT, G. W., & POSTMAN, L. The Psychology of Rumor. New York: Holt, 1947. Pp. 247.

FREUD, A., *et al.* (*Editors*). The Psychoanalytic Study of the Child, Vol. II. New York: International, 1947. Pp. 424.

THURSTONE, L. L. Multiple-Factor Analysis. Chicago: Univ. Chicago Press, 1947. Pp. 535.

ALSCHULER, R. H., & HATTWICK, B. W. Painting and Personality: A Study of Young Children. Chicago: Univ. Chicago Press, 1947. Pp. (2 vols.) 590.

VARIOUS AUTHORS. Army Air Forces Aviation Psychology Program Research Reports. (Many volumes by various authors. A review may concern only one significant volume, or may involve the entire series.) Washington: U. S. Printing Office, 1947.

MURPHY, G. Personality. New York: Harper, 1947. Pp. 999.

ADRIAN, E. D. The Physical Background of Perception. Oxford: Clarendon Press, 1947. Pp. 95.

SNYDER, W. U. Casebook of Non-Directive Counseling. Boston: Houghton Mifflin, 1947. Pp. 339.

AXLINE, V. M. Play Therapy. Boston: Houghton Mifflin, 1947. Pp. 379.

HALSTEAD, W. C. Brain and Intelligence. Chicago: Univ. Chicago Press, 1947. Pp. 206.

RYAN, T. A. Work and Effort. New York: Ronald Press, 1947. Pp. 323.

KINSEY, A. C., POMEROY, W. B., & MARTIN, C. E. Sexual Behavior in the Human Male. New York: Saunders, 1947. Pp. 804.

BARTLEY, S. H., & CHUTE, E. Fatigue and Impairment in Man. New York: McGraw-Hill, 1947. Pp. 429.

NEWCOMB, T. M., & HARTLEY, E. L., *Eds.* Readings in Social Psychology. New York: Holt, 1947. Pp. 672.

BRENMAN, M., & GILL, M. M. Hypnotherapy. New York: International Univ. Press, 1947. Pp. 276.

CRITICAL REVIEWS OF RECENT BOOKS

The Journal of Genetic Psychology, 1947, 71, 261-268.

(Gesell A., & Ilg, F. L. The Child from Five to Ten. New York: Harper, 1946. Pp. 475.)

REVIEWED BY W. DRAYTON LEWIS

Value of a study of child growth is determined to a large degree by the richness of the experience which lies behind the volume. The writers of *The Child from Five to Ten*, Dr. Arnold Gesell and Dr. Frances Ilg, and their collaborators, have had an almost if not an unequaled experience with children at the Yale Clinic of Child Development. No one who is at all familiar with the literature of child growth needs any introduction either to the writers or to the contributions which they have made in this field.

This volume endeavors to do for the period of child development from 5 through 9 what the earlier and deservedly popular volume, *Infant and Child in the Culture of Today*, did for infancy and early childhood. The volume does not confine itself to the years designated in the title and, accordingly, does not fall into the error of so many other volumes and present an isolated segment of growth. The writers recognize that development is a unitary process and that any period of development can only be understood in terms of what has preceded. Thus, much space is devoted to a reconsideration of material contained in *Infant and Child in the Culture of Today* in order to give a true picture of child development, that of continuity of growth through the years.

The philosophy of the earlier volume is reiterated and, in that sense, no new viewpoint is presented. Those who are familiar with the preceding work will find merely that the objectives of that volume have been expanded in terms of growth during the years 5 to 10.

The years, 5 to 10, have had too little attention from students of child development and this work fills a needed place in the literature. Previous studies of this period have been concerned largely with specific problems and there has been little effort to present a unified picture. The fundamental value of this volume, especially to those who are familiar with the philosophy of *Infant and Child in the Culture of Today*, is that it sum-

marizes a great deal of material, pertaining to a later period of development, garnered from extensive case study records of children from the files of the Yale Clinic of Child Development. Any one who is dealing with children of these ages can refer profitably many times to this material.

The fundamental thesis is the necessity of recognizing that the child grows, that those who are dealing with children must seek continually to determine the maturity level of each child, that is, the point the child has attained in the growth continuum. An additional thesis is that each child has a unique and distinctive pattern of growth which makes him an individual and which must be determined if the child is to be dealt with intelligently. Each child, we are told, is his own best norm." "He is never so much like himself as when he is changing, because his growth characteristics are the truest index to his individuality" (29).

The volume ends with "A Philosophic Postscript" which reemphasizes the importance of a philosophy of child growth. It is important because "the temper and the techniques of child care depend primarily upon the underlying philosophic outlook." The philosophy of child growth set forth is called "developmentalism." It is held to be fundamentally a democratic philosophy, "the very opposite of fascism," "for it acknowledges the individuality of the child and wisely concedes that all his behavior is subject to the natural laws of human growth." The fundamental objective is "to do justice to the child's personality" and this makes it imperative that we think "in terms of growth, in terms of his developmental maturity." "This means a philosophy which recognizes the relativities of the life cycle" (p. 452). It is hard to see how any one could question seriously the fundamental validity and even necessity of such a philosophy in this day and age.

The emphasis on individual growth patterns is not as distinctive, nor is it given the emphasis as in *Infant and Child in the Culture of Today*. It is there, nevertheless, and is of fundamental importance for an understanding of the material. If there is a weakness to the volume it lies in the fact that individual differences, although always immanent and fundamental, are not brought to the clear-cut focus as in the earlier volume.

The writers point out that the information brought together in this volume is the result of years of clinical study of children, that the two volumes supplement each other and are, in a sense, companion volumes. The fundamental tenets of the earlier volume are carefully reemphasized for the benefit of readers who are not familiar with their philosophy. However, one who is deeply interested in the total picture of the growing child

will want to read *Infant and Child in the Culture of Today,* for its approach is fundamental. This is true even for those whose primary interest is in the years 5 to 10. They will understand fully the older child only when they have made themselves familiar with earlier development. The reader who is short of time will find that this volume gives a fairly adequate picture of the process of development since some space is devoted to development during the first four years. Part One provides a rapid summary of the fundamental philosophy of the writers, and the first chapter of Part Two provides a brief summary of development during the first four years.

The approach is, obviously, longitudinal and the methods are those of the clinic rather than rigorously experimental and statistical. The work is the outcome of the study of individual children over a period of years. This does not mean that the volume is merely a series of case studies. It is not. Rather, the writers tried to bring together the distinctive characteristics of each age group, as manifested by numerous children, and give a picture of typical behavior for each period. It is admitted that the relief may be too bold, that the picture may be overdrawn, at times, for purposes of emphasis. "But to paint a vivid and usable maturity portrait, we must dip our brush where the pigment is strong" (89). The justification for this over-emphasis is that it makes possible a picture of growth and development which otherwise would not be possible.

Growth is held to be continuous, with no breaks between the age groups treated in the two volumes. A fundamental thesis is that the development from 5 to 10 is continuous with and just as lawful as growth during the first four years. The transformations, as revealed by an analysis of their numerous behavior records, were found to be "gradual and not dramatically obvious." The important finding is that "the growth of the mind is lawfully patterned in the years from five to ten" (p. x).

The writers endeavor to present growth gradients in such a way that the reader will see that each year represents a step, or steps, toward maturity, that the child is growing continually. One who deals with children realizes, of course, that, as a rule, most of the transformations come so steadily that, one who sees the child constantly is scarcely aware of the changes at the time they occur. "Yet they come with such unremitting surety that each birthday marks a significant advance. Each year brings changes in the maturity picture" (p. 60).

Growth, while continuous, is pictured as characteristically spiral, rather than linear. "Progress does not proceed in a straight and steady line.

There are many fluctuations and apparent lapses, due chiefly to the ever changing accents and patterns of growth" (p. 248). Behavior appears, at times, which the uninitiated may judge to be less mature forms of behavior but which, if seen in the proper perspective, are recognized as steps toward maturity.

The major thesis, that the child is moving continuously toward maturity, is emphasized and reemphasized. The authors repeatedly point out that one must try to see each act in the child's development as a step towards maturity, as development due to his unique growth process. The child is incomplete, but growing and maturing and giving indications of the adult he is to be. Immaturity is merely more evident at some ages than at others. The 5-year-old, while by no means a finished product, "already gives token of the man (or the woman) he (or she) is to be. His capacities, talents, temperamental qualities and his distinctive modes of meeting the demands of development,—have all declared themselves to a significant degree. He is already stamped with individuality" (p. 62).

This is definitely not a volume about exceptional children. The purpose is to give a picture of the development of normal children who are living under conditions in the home, school, and community that make for normal development. There will be children whose development is exceptional, who cannot be placed in the series of growth gradients. The gradients can be exceedingly helpful to those who are dealing with problems which are typical of the vast majority of children.

Behavior profiles are presented for each age, 5 through 9. There is over-emphasis and, without doubt, many children will not show the sharply defined patterns of growth which are presented in the profiles. The profiles must be read in that light. The distinctive character of the profiles can best be shown by "key" statements from each age level so I quote at length.

> The 5-year-old is self-contained, on friendly terms with his environment. . . . Meanwhile there is an interlude when he feels quite at home in his world. What is his world? *It is a here-and-now-world.* . . . Five is a nodal age and also a kind of golden age for both parents and child. For a brief period the tides of development flow smoothly. (p. 63). Five is a great talker (p. 66).

> The sixth year (or thereabouts) brings fundamental changes, somatic and psychological. It is an age of transition. . . . These changes manifest themselves in new and sometimes startling psychological traits (p. 89). He tends to go to extremes,—under slight stress, whenever he

attempts to use his most recently acquired powers (p. 90). He does not wish his environment to deviate from a familiar set pattern (96). These traits are vaguely characterized by such adjectives as impulsive, undifferentiated, volatile, dogmatic, compulsive, excitable (p. 97).

There is a kind of quieting down at seven. . . . It is an assimilative age, a time for salting down accumulated experience and for relating new experiences to old (p. 131). . . . Seven is a pleasant age, if one respects the feelings of the child (p. 132). . . . He is becoming aware not only of himself, but of others. He is increasingly sensitive to the attitudes of others (p. 133).

Eight again is expansive but on a higher level of maturity (p. 159). Eight is more of a person by adult standards and in terms of adult-child relationships. . . . There are three traits which characterize the dynamics of his behavior: Speediness, Expansiveness, "Evaluativeness." The last named cannot be found in the dictionary, but it describes his dominant tendency to appraise what happens to him and what he causes to happen (p. 160). As a hungry amoeba thrusts out one pseudopod after another, the hungry 8-year-old mind actively spreads into new territory (p. 164). . . . Intellectually he is becoming more expansive (p. 166).

The behavior trends of the eighth year come to clearer issue; the child gets a better hold upon himself; he acquires new forms of self-dependence which greatly modify his relations to his family, to school and classmates and to the culture in general (pp. 188-9). . . . *Self-motivation* is the cardinal characteristic of the 9-year-old. It is the key to understanding him on his progress toward maturity (p. 189). . . . He shows considerable ability in social criticism as well as self-criticism (p. 190).

A chapter is devoted to each age, 5 through 9, with a brief sketch of the tenth year. The first part of these chapters is a behavior profile, the general trends of which are best illustrated by the quotations just presented. The second half deals with "Maturity Traits." These are summaries of characteristic behavior of the various age groups. They are presented under several headings, namely: motor characteristics, personal hygiene, fears and dreams, self and sex, interpersonal relations, play and pastimes, school life, ethical sense, philosophic outlook. These should be particularly helpful to those who are baffled, at times, by the child's behavior. Problems tend to disappear when one realizes that the behavior that they are troubled about simply is typical for the child of that age, that the behavior merely represents a passing stage in the growth process. "Maturity traits" and "growth gradients" should add greatly to an understanding of child behavior, as well as prevent a great deal of concern and worry on the part of adults, if they are approached with intelligence and understanding.

Part Three devotes a chapter to each of the "maturity traits" listed above, showing significant "growth gradients" from birth to 10. Each chapter begins with a general discussion of the development of the traits. This serves as an introduction to the "growth gradients." A "growth gradient" is defined as "a series of stages or degrees of maturity by which a child progresses toward a higher level of behavior." These are given at intervals of four to six weeks for the first 18 months, for 6-month intervals through the fourth year and then at yearly intervals.

These gradients, it is emphasized frequently, are not to be interpreted as norms. They are not. It is unfortunate that norms have been so overemphasized in the past that they are still often misunderstood, for one who does not understand the significance of norms will probably misinterpret a great deal of this volume. One *must* understand the significance of norms and know how to use them if this volume is to be read with intelligence.

> This does *not* mean that the itemized gradient levels should be regarded as statistical age norms (p. 221). The parent who reads a gradient should never say my child *ought* to be at this particular level of the gradient because he is old enough. The child may well be younger or older than the chronological age assigned by the gradient. It is more important to find the gradient-level which approximately describes the stage of maturity which he has actually attained. The gradients are intended to show the overall developmental *sequences* of behavior rather than rigid standards of expectancy. Individual differences are too great to permit rigid standards rigidly applied. Generous allowances should be made for age variations (pp. 221, 223).

The "growth gradients" are subdivided. Typical, are the subdivisions of *motor characteristics;* bodily activity and eyes and hands; of *personal hygiene;* eating, sleeping, elimination, bath and dressing, health and somatic complaints, and tensional outlets. The chapter on *interpersonal relationships* is one of the best and deals with such "growth gradients" as mother-child, father-child, sibling, family, manners, teacher-child, child-child, and groupings-in-play relationships.

A very significant feature of the volume is that it does not lift a segment of development out of its context, as do most books which deal with segments of development. The emphasis is on the fact that normal growth can only be understood as a process which begins at birth and continues without significant breaks. The besetting sin of a great deal of the material available is that the age segments dealt with are presented completely out of context, thus giving the reader an incomplete viewpoint. The writers of this volume are not guilty of this error.

The book was written with a wide range of readers in view: "parents and teachers, physicians and nurses and others who are professionally responsible for safe-guarding the developmental welfare of children from 5 to 10." One who deals with children of these ages should be able to profit from the material presented. So much material is summarized that it cannot be compassed in a single reading and, for one who is dealing continually with children of these ages, it will be necessary to refer to the material time and again. It will probably not have as wide a reading public as *Infant and Child in the Culture of Today.* Its appeal will not be as wide simply because there is not the wide-spread interest in 5 to 10 as there is in infancy and early childhood. The volume, nevertheless, should have a wide appeal. It is one of those volumes that one must be familiar with if he is to have any claim to being well-versed in child development.

The style is exceedingly well suited to the material and philosophy. Sentences are short, as a rule, and are well adapted to conveying to the reader the impression of movement and growth. An understanding of the material by those who have to deal with children and their problems as they move toward maturity will alleviate much worry and strain for they will come to understand that certain forms of behavior are normal, and to be expected, rather than manifestations of something essentially evil and vicious in the child.

I am not particularly concerned here with criticisms which might be made of the volume. Many, no doubt, will repeat the criticism made of all of Gesell's work, that is, that the norms are too high since he has dealt with a selected group of children from relatively high socio-economic status. This is admitted, but the criticism is not particularly pertinent. The reader is repeatedly warned as to the proper use of norms. It is repeatedly emphasized that the gradients are to be used only as guides.

> The ages assigned to the stages in the foregoing gradients represent average normative trends (p. 23). . . . The significance of any child's behavior must be adjusted in terms of its form and its position in a sequential gradient. . . . The purpose is rather to find his (the child's) approximate position in various sequences of development (p. 26). The child is his own best norm (p. 29).

It is obvious that no book can be written that is at all significant which will be understood equally readily by all readers. Most readers who deal with children will profit from some of the material but, in the end, there is no substitute for intelligence in interpreting and understanding material

such as is found in this volume. The reader will have to be intelligent enough to apply the material to the individual child, since children do develop at different rates and since a specific child probably will not develop like other children. There is material here which will be of value even to mature readers well-versed in child development.

Some will object to the amount of repetition. There is a great deal of repetition but I believe that it is necessary repetition. It repeats much of the previous volume and it also repeated within itself. This is done by way of emphasis and to give clear pictures of different phases of development. Some of it is called for by the very structure of the work but many readers will want to do some judicious skipping.

The authors frequently weaken their presentation by introducing theoretical explanations, that is, by explaining some stage of development as a phase of the evolutionary process. The main strength of the work is that it is fundamentally a factual presentation and often the phylogenetic explanations do not fit into the picture and confuse the issue rather than clarifying it. The volume is at its best when it deals with ontogeny and does not wander afield into phylogeny.

The reader who is already familiar with the philosophy and previous works of these writers will not profit from much of the material since it will already be familiar to him. This is particularly true for the one who has read *Infant and Child in the Culture of Today*. This is not to be taken to mean that the volume is merely a rehashing of the earlier work. It is not. The "growth gradients" and "maturity traits" for the years 5 through 9 are new material and they are made more meaningful by being placed in proximity with the gradients which are repeated from the earlier work.

The significance of the work is beyond question. It has a place in the literature of child development. It is not a textbook, but is fundamentally a volume that one will want to read and then keep at hand for reference to specific sections as the need arises.

Southwestern Louisiana Institute
Lafayette, Louisiana

BOOKS RECENTLY RECEIVED

(There will always be two pages of book titles, listed in the order of receipt, i.e.; the most recently received books will be found at the end of the list.)

CLAWSON, J. Psychology in Action. New York: Macmillan, 1946. Pp. 289.
THOMAS, D. S., & NISHIMOTO, R. The Spoilage. Berkeley: Univ. California Press, 1946. Pp. 388.
MICHOTTE, A. La Perception de la Causalite. Paris: Vrin, 1946. Pp. 296.
NATIONAL OPINION RESEARCH CENTER. Proceedings. Denver: Univ. Denver, 1946. Pp. 108.
CARTER, L. F. Psychological Research on Navigator Training. Washington: U. S. Printing Office, 1947. Pp. 186.
LEPLEY, W. M. Psychological Research in the Theatres of War. Washington: U. S. Printing Office, 1947. Pp. 202.
DAVIS, F. B. The AAF Qualifying Examination. Washington: U S. Printing Office, 1947. Pp. 266.
SHERIF, M., & CANTRIL, H. The Psychology of Ego-Involvements. New York: Wiley, 1947. Pp. 525.
SOROKIN, P. A. Society, Culture and Personality. New York: Harper, 1947. Pp. 742.
WHITE, L. The American Radio. Chicago: Univ. Chicago Press, 1947. Pp. 260.
KRACAUER, S. From Caligari to Hitler. Princeton: Princeton Univ. Press, 1947. Pp. 361.
ARCHIBALD, K. Wartime Shipyard. Berkeley: Univ. California Press, 1947. Pp. 237.
THURSTONE, L. L. Multiple-Factor Analysis. Chicago: Univ. Chicago Press, 1947. Pp. 535.
LINDNER, R. M., & SELIGER, R. V. Handbook of Correctional Psychology. New York: Philosophical Library, 1947. Pp. 691.
CATTELL, R. B. Description and Measurement of Personality. New York: World Book, 1946. Pp. 602.
ALSCHULER, R. H., & HATTWICK, B. W. Painting and Personality. (2 vols.) Chicago: Univ. Chicago Press, 1947. Pp. 590.
FORD, M. The Application of the Rorschach Test to Young Children. Minneapolis: Univ. Minnesota Press, 1946. Pp. 114.
RADKE, M. J. The Relation of Parental Authority to Children's Behavior and Attitudes. Minneapolis: Univ. Minnesota Press, 1946. Pp. 123.
WATSON, G. Action for Unity. New York: Harper, 1947. Pp. 165.
COLE, L., & MORGAN, J. J. B. Psychology of Childhood and Adolescence. New York: Rinehart, 1947. Pp. 416.
PORTEUS, S. D. And Blow Not the Trumpet. Palo Alto: Pacific Books, 1947. Pp. 304.
SEWARD, G. H. Sex and the Social Order. New York: McGraw-Hill, 1946. Pp. 301.
FLUGEL, J. C. Men and Their Motives. New York: Internat. Univ. Press, 1947. Pp. 289.
MANNHEIM, H. Criminal Justice and Social Reconstruction. New York: Oxford Univ. Press, 1946. Pp. 290.
LEIGHTON, D., & KLUCKHOHN, C. Children of the People. Cambridge: Harvard Univ. Press, 1947. Pp. 277.
KITAY, P. M. Radicalism and Conservatism toward Conventional Religion. New York: Teach. Coll., Columbia Univ., 1947. Pp. 117.
LANDES, R. The City of Women. New York: Macmillan, 1947. Pp. 248.
DICHTER, E. The Psychology of Everyday Living. New York: Barnes & Noble, 1947. Pp. 239.
FREUD, A., *et al.* The Psychoanalytic Study of the Child, Vol. II. New York: Internat. Univ. Press, 1947. Pp. 424.
GILBERT, G. M. Nuremberg Diary. New York: Farrar, Straus, 1947. Pp. 471.
LANDIS, P. H. Social Policies in the Making. Boston: Heath, 1947. Pp. 554.

THOMPSON, L. Guam and Its People. Princeton: Princeton Univ. Press, 1947. Pp. 367.

VON HENTIG, H. Crime: Causes and Conditions. New York: McGraw-Hill, 1947. Pp. 379.

BOWERMAN, W. G. Studies in Genius. New York: Philosophical Library, 1947. Pp. 343.

ALLPORT, G. W., & POSTMAN, L. The Psychology of Rumor. New York: Holt, 1947. Pp. 247.

FOX, H. M. The Personality of Animals. New York: Penguin, 1947. Pp. 116.

SNYDER, W. U. Casebook of Non-Directive Counseling. Boston: Houghton Mifflin, 1947. Pp. 339.

JUROVSKY, A. Sulad V Rodinnom Zivote (Harmony in Family Life). Bratislava: Martin, 1946. Pp. 268.

DENNIS, W., *et al.* Current Trends in Psychology. Pittsburgh: Univ. Pittsburgh Press, 1947. Pp. 225.

WICKERT, F., *Ed.* Psychological Research on Problems of Redistribution. (Report No. 14.) Washington: Army Air Forces Aviation Psychology Program Research Reports, 1947. Pp. 298.

SHERMAN, M. Psychology for Nurses. New York: Longmans, Green, 1947. Pp. 237.

MERRILL, M. A. Problems of Child Delinquency. Boston: Houghton Mifflin, 1947. Pp. 403.

MURPHY, G. Personality. New York: Harper, 1947. Pp. 999.

WHITE, W. Psychology in Living. New York: Macmillan, 1947. Pp. 393.

ZUNINI, G. Animali E Uomo: Visti Da Uno Psicologo. Milano: Societa Editrice, 1947. Pp. 293.

GEMELLI, A., & ZUNINI, G. Introduzione Alla Psicologia. Milano: Societa Editrice, 1947. Pp. 447.

HOBBS, N., *Ed.* Psychological Research on Flexible Gunnery Training. (Report No. 11.) Washington: Army Air Forces Aviation Psychology Program Research Reports, 1947. Pp. 508.

ESTABROOKS, G. H. Spiritism. New York: Dutton, 1947. Pp. 254.

NAUMBURG, M. Studies of the "Free" Art Expression of Behavior Problem Children and Adolescents as a Means of Diagnosis and Therapy. New York: Coolidge Foundation, 1947. Pp. 225.

BURCH, G. I., & PENDELL, E. Human Breeding and Survival. New York: Penguin, 1947. Pp. 138.

THORNDIKE, R. L., *Ed.* Research Problems and Techniques. (Report No. 3.) Washington: Army Air Forces Aviation Psychology Program Research Reports, 1947. Pp. 163.

ADRIAN, E. D. The Physical Background of Perception. Oxford: Clarendon Press, 1947. Pp. 95.

PEATMAN, J. G. Descriptive and Sampling Statistics. New York: Harper, 1947. Pp. 577.

GIBSON, J. J., *Ed.* Motion Picture Testing and Research. (Report No. 7.) Washington: Army Air Forces Aviation Psychology Program Research Reports, 1947. Pp. 267.

WOODWORTH, R. S., & MARQUIS, D. G. Psychology. New York: Holt. Pp. 677.

KRAINES, S. H., & THETFORD, E. S. Managing Your Mind. New York: Macmillan, 1947. Pp. 374.

PELLMAN, C. Overcoming Stammering. New York: Beechhurst, 1947. Pp. 160.

AXLINE, V. M. Play Therapy. Boston: Houghton Mifflin, 1947. Pp. 379.

Genetic Psychology Monographs (*continued*)

VOLUME 23—January-June, 1941

1. An analysis of certain variables in a developmental study of language—F. M. Young
2. [illegible]
3. An analysis of the mental factors of various age groups from nine to sixty—B. Balinsky
4. Factors influencing performance on group and individual tests of intelligence: I. Rate of work—M. V. [illegible]
5. Individual differences in apperceptive reaction: a study of the response of preschool children to pictures—E. W. Amen

VOLUME 24—July-December, 1941

1. Twins T and C from infancy to adolescence: a biogenetic study of individual differences by the method of co-twin control—A. Gesell and H. Thompson
2. [illegible]
3. An experimental study of the factors of maturation and practice in the behavioral development of the embryo of the frog, *Rana pipiens*—A. Fromme
4. [illegible]
5. Measurement of the size of general English vocabulary through the elementary grades and high school—M. K. Smith
6. Stereotypes in the field of musical eminence—P. R. Farnsworth

VOLUME 25—January-June, 1942

1. A study of factors determining family size in a selected professional group—J. C. Flanagan
2. A genetic study of geometrical-optical illusions—Amelia A. Walters
3. Interpretation of behavior-ratings in terms of favorable and unfavorable deviations: a study of scores from the [illegible]—[illegible]
4. [illegible]
5. An investigation of the intelligibility of the speech of the deaf—C. V. Hudgins and F. C. Numbers

VOLUME 26—July-December, 1942

1. The critical frequency limen for visual flicker in children between the ages of 6 and 18—V. L. Miller
2. Some factors determining handedness in the white rat—K. L. Wentworth
3. Motivation and behavior—E. Frenkel-Brunswik

VOLUME 27—January-June, 1943

1. Comparison of children's personality traits, attitudes, and intelligence with parental occupation—N. R. Maddy
2. A comparative study of mental functioning patterns of problem and non-problem children seven, eight, and nine years of age—M. L. Pignatelli

VOLUME 28—July-December, 1943

1. Separation anxiety in young children: a study of hospital cases—H. Edelston
2. Correlates of vocational preferences—W. A. Bradley, Jr.

VOLUME 29—January-June, 1944

1. [illegible]
2. A twin-controlled experiment on the learning of auxiliary languages—[illegible]

VOLUME 30—July-December, 1944

1. A method of administering and evaluating the thematic apperception test in group situations—R. M. Clark
2. A study of anxiety reactions in young children by means of a projective technique—R. Temple and E. W. Amen

VOLUME 31—January-June, 1945

1. The evolution of intelligent behavior in rhesus monkeys—B. Weinstein
2. [illegible]: An experimental study by means of the Rorschach technique—[illegible]

VOLUME 32—July-December, 1945

1. A clinical study of sentiments: I—H. A. Murray and C. D. Morgan
2. A clinical study of sentiments: II—H. A. Murray and C. D. Morgan

VOLUME 33—January-June, 1946

1. Interpretation of spontaneous drawings and paintings—T. S. Waehner
2. Preferences for sex symbols and their personality correlates—K. Franck
3. [illegible]

VOLUME 34—July-December, 1946

1. The relation of emotional adjustment to intellectual function—J. L. Despert and H. O. Pierce
2. [illegible]
3. Finger-painting and personality diagnosis—P. J. Napoli

VOLUME 35—January-June, 1947

1. The thematic apperception technique in the study of culture-personality relations—W. E. Henry
2. [illegible]
3. [illegible]

VOLUME 36—July-December, 1947

1. Maze test validation and psychosurgery—S. D. Porteus and R. D. Peters
2. Diagnostic implications of Rorschach's Test in case studies of mental defectives—I. Jolles

THE JOURNAL PRESS
2 Commercial Street
Provincetown, Massachusetts
U. S. A.